

Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

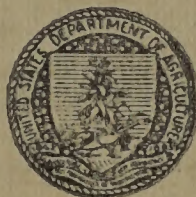
RESEARCH OF THE
EXPERIMENT STATIONS

MAY 16 1924

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

F764T

TRAIL CONSTRUCTION ON THE NATIONAL FORESTS



1
P769T

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

TRAIL CONSTRUCTION ON THE NATIONAL FORESTS



C O N T E N T S.

	Page.		Page.
Purpose.....	3	Marking.....	46
Policy and general instructions.....	3	Blazing.....	46
Relative needs.....	3	Sign posting.....	49
Progress.....	3	Miscellaneous practices.....	52
The job.....	4	Practice.....	53
Place of forest officers.....	4	Maintenance.....	56
Use of handbook.....	4	Policy.....	56
Purpose of trails.....	5	Classification.....	56
Standards.....	5	Dangerous places.....	57
Selection of project.....	6	Relocating.....	58
Trail crews as fire fighters.....	7	Improving grades on broad ridges.....	58
Plows and scrapers.....	8	Removal of obstacles from the tread.....	58
Plans.....	8	Specifications for construction apply in maintenance.....	58
Classification and specifications.....	9	Organization for maintenance.....	62
Location.....	10	Ordinary.....	62
Estimates.....	13	Extraordinary.....	62
Construction.....	14	Decrease of maintenance.....	62
Staking.....	14	Maintenance units.....	63
Grades.....	14	Bridges.....	63
Size and organization of crews.....	16	Stringer bridges.....	64
Camps.....	18	King truss bridge.....	67
Clearing.....	18	Appendix.....	71
Brush disposal.....	19	Tools.....	71
Width of trail.....	19	Suggested lists of tools and equipment.....	71
Rock slides.....	28	For earth work.....	71
Turnouts.....	28	For rock work.....	72
Back slopes.....	31	Blacksmith outfit.....	72
Switchbacks.....	34	Cobbler's outfit.....	72
Rock walls.....	32	Tools for small bridges which will be built, ordinarily, by	
Drainage.....	36	trail crews.....	73
Open ditches.....	36	Tools and equipment for erecting large timber bridges—	
Water bars.....	36	suspension or truss.....	73
Culverts.....	41	Tools for constructing wooden bridges for five-man crew..	74
Corduroy.....	41	Tentage.....	76
Fords.....	45		

ILLUSTRATIONS.

	Page.		Page.
Fig. 1.—Principles to be observed in locating trails.....	12	Fig. 21.—Profile of grade line at water bars.....	38
Fig. 2.—Trails constructed from marked and unmarked grade lines.....	15	Fig. 22.—Section of trail showing water break log.....	39
Fig. 3.—Showing trail on top of a ridge.....	17	Fig. 23.—Trails cross arroyos, draws and ravines.....	40
Fig. 4.—When not to remove stumps.....	20	Fig. 24.—Trail on flat soft wet grounds.....	42
Fig. 5.—How to measure width of trail.....	21	Fig. 25.—Section of split corduroy.....	43
Fig. 6.—Cross section of typical trail on slopes between 30 and 85 per cent.....	23	Fig. 26.—Views of ordinary sill and stringer corduroy.....	44
Fig. 7.—Cross section of typical trail on slopes between 85 and 185 per cent.....	24	Fig. 27.—Trail blaze.....	47
Fig. 8.—Trail construction around bluffs.....	25	Fig. 27a.—Trail blaze.....	48
Fig. 9.—Type of trail suited to regions of heavy rains.....	26	Fig. 28.—Examples of careless practice in placing signs.....	50
Fig. 10.—Inapplicable construction in Southwest.....	27	Fig. 29.—Neatly placed signs.....	50
Fig. 11.—Trails on rubble consisting of small rocks.....	29	Fig. 30.—Examples of duplication in placing signs.....	50
Fig. 12.—Trails on rubble consisting of large rocks.....	30	Fig. 31.—Post for sign board.....	51
Fig. 13.—Economical method of clearing for pack and stirrup.....	31	Fig. 32.—Method of setting posts for signs.....	51
Fig. 14.—Desirable width of turn and guard rail.....	33	Fig. 33.—Abandonment of existing trails on side hills.....	59
Fig. 15.—Rock wall to prevent cross cutting on turns.....	34	Fig. 34.—Abandonment of existing trails on ridges.....	60
Fig. 15a.—Cross section showing use of dirt rail on turns.....	34	Fig. 35.—Improving grade on flat ridge.....	64
Fig. 16.—A typical unavoidable depression requiring walls.....	35	Fig. 36.—Approved style of stringer bridge.....	65
Fig. 17.—Showing an intermediate layer of rocks in walls.....	35	Fig. 37.—End view of stringer bridge.....	65
Fig. 18.—Cross section of a correctly laid wall.....	35	Fig. 38.—Plan of stringer bridge.....	65
Fig. 19.—Completed wall.....	35	Fig. 39.—Plan of King truss bridge.....	68
Fig. 20.—Trail provided with a drainage ditch.....	37	Fig. 39a.—Design of log crib pier, rock filled.....	69
		Fig. 40.—Trail drag.....	70

TRAIL CONSTRUCTION ON THE NATIONAL FORESTS.

PURPOSE.

1. The purpose of this handbook is, first, to state a general policy of trail construction and maintenance; second, to establish a uniform classification of National Forest trails according to their use; third, to establish standard specifications for each class; and, fourth, to describe and illustrate for purposes of reference and application approved methods of location, construction, and upkeep.

POLICY AND GENERAL INSTRUCTIONS.

RELATIVE NEEDS.

2. In making many of the National Forests more accessible, the first and largest need is for secondary trails—ways through the woods. The second important but less urgent need is for primary trails. To maintain the present degree of accessibility by adequate upkeep of existing trails is more important as a general rule than the building of additional mileage.

PROGRESS.

3. The progress made in trail work will depend, first, on the amount of money available, and, second, on the capacity of the available organization to direct and control such work properly.

THE JOB.

4. Trail location and construction is relatively a simple job. Money, proper workmanship, common sense, abundant energy, and simple tools and equipment are the only requisites to good work. The employment of location and supervising engineers and specially organized survey parties and the use of precise methods involving technical practices such as accurate leveling, transit work, detailed field notes and profile maps of location, have no place in the trail program.

PLACE OF FOREST OFFICERS.

5. Responsibility for selection of the projects, correct location, and adequate supervision must rest squarely upon the supervisor. Supervisors, deputies, and district rangers will do at least the major part of the preliminary location work and they will give such supervision to crews as may be necessary to get the work done in accordance with established policy and practice.

6. It is recognized as proper and meritorious for rangers to work alone or in groups on actual trail construction or in direct charge of trail crews during the so-called inactive season, and at other times if it will not interfere with fire control and administrative work.

USE OF HANDBOOK.

7. It is recognized that to prescribe rules or to outline methods of construction to cover all details or to fit all the varying conditions encountered is not possible. No attempt to do it has been made in this handbook. The points covered and instructions given are confined to the more obvious and major principles of trail construction. They are based on methods and principles which have proved their worth; furthermore, experience has proved their general applicability.

8. Field officers are not expected to memorize the contents of this handbook. It is expected, however, that field officers will always remember: First, the handbook is available; second, it is to be consulted and studied before starting a job; third, every man placed in charge of trail work will have a copy of it supplemented by written instructions to indicate the parts of the handbook that are applicable to his job; fourth, the instructions it contains will govern on the job, unless physical conditions clearly prevent.

Burden of proof of inapplicability will always be upon the officer who is responsible for getting the work done. Officers should expect to be held personally responsible for unwarranted deviation.

PURPOSES OF TRAILS.

9. Trails will be maintained, reconstructed, and constructed in the interests of: (a) Fire control; (b) administration; (c) grazing; (d) recreation. The objects of trail construction are (a) to provide safe and unobstructed passage of loaded animals and foot travelers at a walking gait and in single file; (b) durability designed to meet expected use and liability of damage from natural causes.

STANDARDS.

10. Standards of construction designated in this handbook are sufficient to accomplish the justified objects of trail work.

11. The standards of trail upkeep desired are those which are necessary to maintain the standard of construction established herein. Well-balanced work, not polish, is wanted. To underdo maintenance is bad. To overdo it is worse, because a dollar unspent remains available to correct mistakes, while more dollars spent than necessary are simply wasted.

12. Maintenance will include the removal of obstacles from primary trail beds to facilitate the operation of plows and drags wherever the use of such horse-drawn equipment is feasible from the point of view of economy and physical practicability.

SELECTION OF PROJECT.

13. Reconstruction of sections of existing trails will usually have to be justified on the basis of need for, and practicability of, materially increasing possible rate of travel up to the average for the region, or, in other words, time saving, remembering always that loaded pack horses travel at a walk and always in single file. Reconstruction of sections to provide a greater degree of safety, and to reduce very steep pitches as a means of conserving horse flesh may occasionally be warranted, but projects of this kind to merit approval must be founded on fact, not upon an individual's case of nerves.

14. New fire control or administrative projects to warrant approval will have to be based upon:

- (a) Sound reasons for and practicability of reducing travel time into given regions.
- (b) Sound reasons for making a country accessible to animals which is now open to foot travelers only.
- (c) Sound reasons for making particular places accessible to either foot travelers or horses.

15. Recreation trails will ordinarily be constructed only where the need is made clearly apparent by public demand or by existing heavy use of trails over which travel is very laborious or difficult.

16. Grazing projects fall into two classes:

- (a) Development projects.
- (b) Grazing administration projects.

Grazing development projects to justify allotments must be based upon one or more of the following reasons:

- (a) Existing demand for additional range which can be satisfied only by making unused territory accessible by construction of trails.
- (b) Or, a demand which may be depended upon to materialize by the date of completion of a given project.
- (c) To secure proper distribution of stock on allotments, parts of which are overgrazed while other sections are only partially utilized or totally unutilized because of genuine, not relative, inaccessibility. Do not build trails to

overcome inaccessibility which may be met by better salt distribution or proper attention to herding by the owner or his employees.

(d) To make accessible, or to increase accessibility of, unused or slightly used regions of large extent in the interest of fire control, although the anticipated demand is more or less speculative but where nevertheless it may be good business to spend money on stock trails, driveways, and bridges in order to create conditions favorable to stock as an inducement to owners to seek grazing privileges.

Other grazing projects, not of a development nature, will be approved upon showing of real need for:

(a) The building of stock trails (driveways) to protect existing roads or trails used chiefly for other purposes.

(b) The building of stock trails (driveways) or relocation in whole or in part of existing ones in interest of fire control.

(c) The building of stock trails (driveways), or relocation of existing ones to protect recreational use of the National Forests.

(d) Trails needed to facilitate the transportation of supplies used by stockmen.

The standard of stock trails should never exceed, and, with the exception of trails built to facilitate transportation of stockmen's supplies, should seldom equal the specifications for secondary trails.

TRAIL CREWS AS FIRE FIGHTERS.

17. Two principal factors are to be given consideration in laying out a season's trail program:

(a) Effectiveness of trail work.

(b) The availability of men for fire fighters.

Under some circumstances it may be advisable to prolong work on a trail at the sacrifice of speedy completion, or to start work on a trail of secondary importance, in order to have a crew on the ground to form an essential part of

the fire organization. The scheduling of trail construction or repair projects to provide work before and after the fire season for the fire control personnel is also important.

18. Employ men with the definite and unmistakable understanding that they will become a part of the fire-control organization and that they must be ready and willing to go to and to fight fires either day or night. Unless other practice is specifically approved by the district forester, the rate of pay of members of trail crews will not be changed nor will overtime be given while they are on suppression work.

19. Connect trail crews which are considered to be a part of the fire-control organization with the telephone system if practicable, and always equip them with an adequate outfit of fire-fighting tools and with appropriate emergency rations for suppression work.

PLOWS AND SCRAPERS.

20. Use plows and V drags to the fullest practicable extent on construction and maintenance of trails.

21. The light reversible side-hill plow at present is the best known type. Various kinds of V drags are in use. One of satisfactory design is shown in Figure 40.

22. Forest officers are urged to experiment with the view of designing better types of plows and scrapers.

23. If Service-owned animals are not available and private stock can not be rented conveniently, horses and mules should be purchased from trail funds where the use of plows and scrapers is good practice.

24. District foresters are especially urged to get the instructions of this section into practice if use of the equipment mentioned will help reduce costs.

PLANS.

25. A trail plan should be developed for each Forest. The development should proceed only as rapidly as dependable data are gathered from knowledge acquired in the field. Make no attempt to complete the plan simply to have something of the nature to exhibit. Only usable plans have a place in the trail program.

26. A standard form of plan, complete in all details, will not be prescribed. The minimum requirements, however, for each Forest are:

(a) A map on appropriate scale, showing roughly (preferably in crayon) all existing and the entire future development needed so far as can be foreseen. This map will ordinarily be changed frequently, and should, therefore, be simple and inexpensive. It will be known as the "trail-plan map."

(b) Card Form 428 for each project about which enough is definitely known to make a detailed estimate.

(c) A second map to be called the "progress map," showing the location of each completed trail, regardless of origin, and each project listed on Forms 428 to which funds are allotted. This map will be a permanent one.

Roads may be shown on both maps at the option of the district forester.

CLASSIFICATION AND SPECIFICATIONS.

27. Forest Service trails will be classified in two groups:

(a) Primary.

(b) Secondary.

Primary trails are defined as trails over which an average of more than one saddle or pack animal will pass each day during the field season.

Secondary trails are defined as trails which for the ensuing five years will be used by an average of one saddle or pack animal, or less, per day during the field season. This classification will include stub trails and foot trails.

28. Classify every proposed trail before its construction, and all existing trails in advance of reconstruction and maintenance. Specifications of work to be done will be based upon such classification.

29. In classifying trails, keep constantly in mind that past experience proves a tendency to overestimate probable use. Closest guarding of enthusiasm and judgment, also checking by higher officers is necessary to hold future errors

in classification to the minimum. Officers having responsibility for trail planning and construction should expect to be called upon to justify the construction of a primary trail when the volume of travel calls for a secondary trail.

LOCATION.

30. In order to secure best possible topographical and geographical location, always make a thorough reconnaissance of the region or land over which a proposed trail of either class, or sections of old trails proposed for reconstruction, will pass before definitely selecting the route for a project. Too much emphasis can not be given to the importance of this phase of trail work.

31. During the reconnaissance survey, always definitely select and locate control points, and get their elevation and approximate intervening distances.

32. The instruments needed in trail reconnaissance, in addition to the ordinary tools of a woodsman, are an Abney level or hypsometer for laying out grades and measuring slopes, and in certain instances an aneroid barometer for ascertaining elevations.

33. With approximate distance and elevation between two control points known, to ascertain the approximate uniform grade between them add two ciphers to the elevation figures and divide by the distance expressed in feet. Example:

$$\begin{array}{l} \text{Elevation difference, 1,250 feet} \\ \text{Distance, } 3\frac{1}{4} \text{ miles, 17,160 feet} \end{array} \left(\frac{125000}{17,160} \right) = 7 \text{ per cent approximate.}$$

34. In trail location as far as practicable—
Avoid:

- (a) Swamps and boggy land.
- (b) Creek bottoms and arroyos subject to damaging floods.
- (c) Slopes subject to snow slides.
- (d) Locations subject to snowdrifts.

Avoid—Continued.

- (e) Slides. (See Fig. 1.)
- (f) Unstable ground.
- (g) Steep slopes.
- (h) Bluffs and rocks.
- (i) Frequent crossings of streams where fording is difficult or impracticable.
- (j) Locations requiring construction of bridges and culverts.
- (k) Heavy clearing.
- (l) Switchbacks, where practicable. In instances where the use of switchbacks is good business, make the legs as long as topography will permit.

Favor:

- (a) Southern exposures.
- (b) Ridges.
- (c) Benches.
- (d) Natural openings.
- (e) Open timber.
- (f) Light stands of brush.

Items (b) to (f), inclusive, should be favored even at the sacrifice of grade.

35. Do not lose sight of the desirability of having trails pass near camping places, horse feed, water, and points which furnish a broad view of the surrounding country. These items are of special importance to recreation and fire-control trails.

36. Always bear in mind that trails are used by a class of travel that is but little affected by undulations and a steep pitch here and there, and that they are not associated with vehicles the carrying capacity of which is limited by

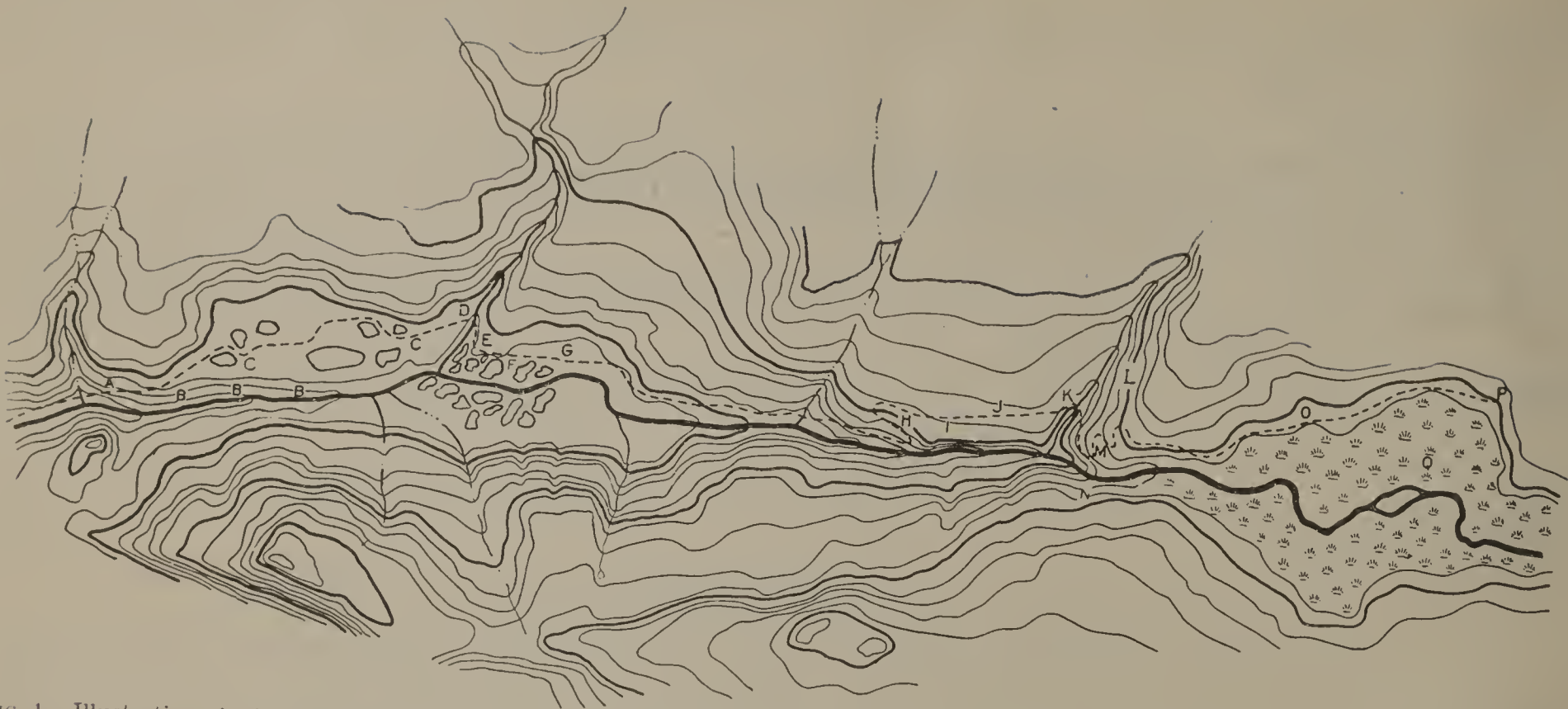


FIG. 1.—Illustration of principles to be observed in locating trails which parallel mountain streams. Reference Paragraph No. 34. A, 15 per cent grade to escape rock and hard land by climbing on to bench; B, rocky and hard; C, bend in trail to escape large rocks; D, 10 per cent minus grade for 200 feet; E, 15 per cent plus grade for 350 feet to shorten trail across canyon with flat bed; F, rocky flat to edge of steep slate side hill; G, 18 per cent slope of side hill, no grading; H, 20 per cent grade for 500 feet to escape bluff; I, bluff of rock; J, 30 per cent slope no grading; K, reverse 8 per cent for 50 feet on each side; L, rocks, tan bark oak and heavy brush; M, open point. Switch backs on 15 per cent to 18 per cent grade to escape rock and tan bark oak side hill; N, water falls and rapids; O, solid ground; P, camp; Q, meadow.

the steepest pitch. Remember, too, that trails are used by foot travelers and saddle or pack animals, traveling single file, and usually in a walk. Lay out trails accordingly, and never be influenced by the idea that later a trail may be converted into a road. *Locate trails as trails, never as bases for future roads.*

ESTIMATES.

37. Accurate estimates of costs of proposed projects based upon knowledge gained by field investigation, and preferably upon data obtained from thorough reconnaissance, should ordinarily be made in advance of allotments. Estimates are expected to be more than mere guesses. A failure to arrive at a reasonably close approximation of the cost of a project is a reflection upon an officer's qualifications.

38. Ordinarily, proposed projects or trail systems should be described in memoranda, boiled down to essential facts. The major elements to be considered and dealt with in a brief common-sense manner are:

- | | |
|--|--|
| (a) Purpose. | (g) Length of corduroy. |
| (b) Length of project. | (h) Number of bridges, brief description of each, and material available for construction. |
| (c) Classification with reasons. | (i) Number and description of signs needed. |
| (d) Types of cover, expressed in miles of each type. | (j) Organization: |
| (e) Statement showing percentage of total distance in: | (1) Size of crew proposed. |
| (1) Blasting ground. | (2) Transportation facilities needed. |
| (2) Digging ground. | (3) Equipment needed. |
| (f) Side slopes: | (4) Forage needed. |
| Per cent of entire distance, 0-30 per cent. | (5) Camping places. |
| Per cent of entire distance, 31-85 per cent. | (k) Period when work should be done. |
| Per cent over 85. | |

Recapitulation in accordance with cost captions of Form 428. Carry the figures of the estimate to Form 428 as projects are tentatively approved.

CONSTRUCTION.

39. Unless otherwise specified the instructions and suggestions under this head apply to both primary and secondary trails.

STAKING.

40. Do not start work on any trail until the route has been definitely chosen after careful reconnaissance and the *main control points* established. Never begin construction on any section of a trail until the location of that section has been marked on the ground by stakes or other plain markers.

41. At intervals of 25 to 50 feet where excavating is to be done, mark the grade line with stakes or some other form of durable indicators. Place the indicators on grade, that is, where digging work starts. On flats and along slopes under 30 per cent where a simple mark will take the place of grading, space stakes or indicators only close enough together to make or correct alignment of the trail and evenness of the grade.

42. To insure an evenly sustained grade between indicators, wherever practicable, have an experienced man with a good eye, preferably the foreman, scratch a narrow line between indicators or stakes. Never start mattock-men or pick-men at work before the grade line has been thus indicated. Have the foreman see to it that graders always use this line as a basis from which to begin work. (Fig. 2.)

GRADES.

43. No standard gradients are established. Use the grade up to 15 per cent which will result in the least amount of construction or shortest distance between control points. If the shortest route lies along a gradient in excess of 15 per cent for more than one-half mile, cut the grade down to 15 per cent by increasing the distance, but do not go below 15 per cent.

44. To avoid expensive construction and to get the best location at a justifiable cost, in ascending or descending, use of grades over 15 per cent to a maximum of 30 per cent within the limitation expressed in Table 1 is considered to



FIG. 2.—A, results on a trail constructed from a well marked grade line; B, grade stakes and a mark 2 to 4 inches wide in the earth on grade between them; C, result on a trail not constructed from a marked grade line. (Par. 42.)

be good practice. To accomplish the same object, use of reverse grades up to 30 per cent at reasonable intervals, for distances which will not give a loss of elevation of more than 50 feet in one reverse section is also good business.

TABLE 1.—*Grades above 15 per cent.*

Grade (per cent).	Distances ordinarily permissible.
16 to 20.....	One-half mile.
21 to 25.....	One-fourth mile.
26 to 30.....	100 yards.

45. Along creeks of slight fall or in paralleling the contour of a mountain, make no effort to maintain uniform grades if construction cost can be materially reduced, without material decrease in rate of travel. By use of undulating grades to a reasonable extent avoid bluffs, slides, and exceedingly steep slopes. (See Fig. 1.)

46. Along ridges and points always use the crest of the ridge if its ups and downs do not exceed an approximate average of 15 per cent for distances greater than those shown in Table 1, or if the crest is not obstructed by a series of projecting bluffs or rocks. (Fig. 3.)

47. The only permissible exceptions to the grade limits stated are the stub trail and foot trail which probably never will become a part of a primary trail. For stub trails use any percentage of grade passable to an animal carrying the average load, and in case of foot trails any gradient over which a man with a pack weighing from 15 to 40 pounds can travel conveniently.

SIZE AND ORGANIZATION OF CREWS.

48. Crews composed of eight or ten men, including foreman and cook, are the most economical on heavy construction. If work is to be rushed, use two or more separate crews of this size on sections worked from different camps rather than one large crew.

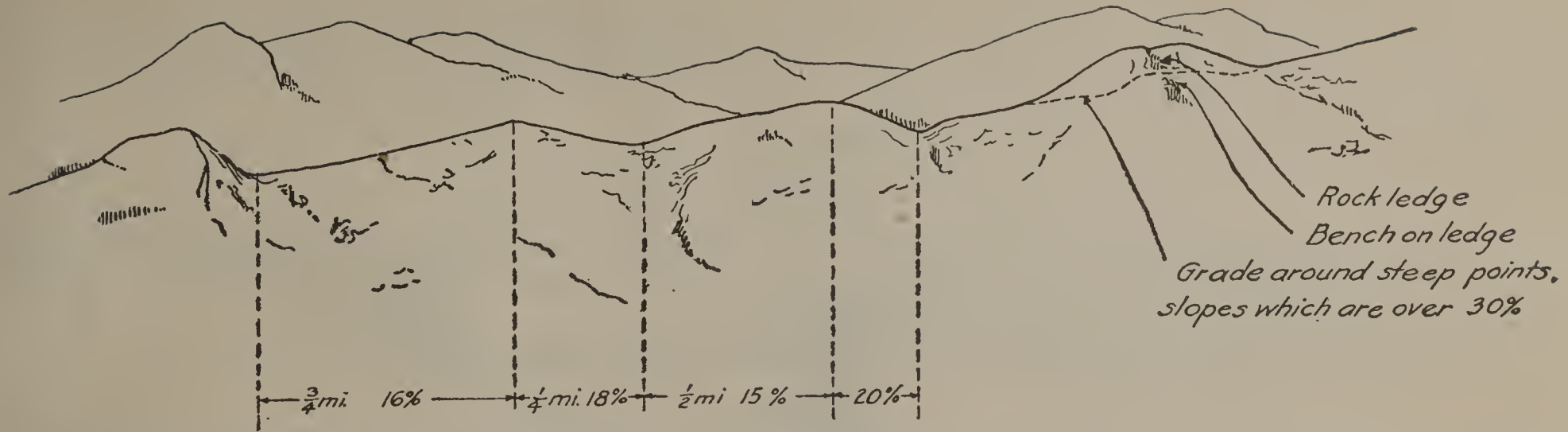


FIG. 3.—Showing top of a ridge. On such locations follow top, reference paragraph No. 46. Stock do less damage and maintenance to tread is negligible. Where obstruction prevents use of ridge crest, grade only sufficient trail to get around them. (Par. 46.)

49. Plan to have blacksmithing done either by the foreman or the powder man rather than by any other workman.
50. Work swampers at least two days ahead of graders.
51. See to it that the line designating position of grade between grade indicators is at least one day ahead of graders.
52. Wherever practicable, work graders far enough ahead of rock men so that blasting will not interfere with graders. Assign graders to stations 25 feet, 50 feet, or 100 feet apart. Do not permit them to crowd up.
53. Work rock men and powder men behind graders. Do not blast stumps ahead of graders.
54. The trimmer men following the crew are to smooth up tread, install water breaks, decrease angle of back slopes where they are too steep, and cut any interfering brush left by the swampers.

55. The organization can only be put into operation after the job is well started. Entire crews might clear at the outset in order to get three or four days clearing ahead, then all but the regular swampers will grade until the grading proceeds a safe distance ahead of the blasting work. After grading is well advanced rock men and powder men can be assigned their job. In turn, the trimmers can take up their work.

56. For light work see organization under "Maintenance."

CAMPS.

57. Keep camps as near as possible to the work and never more than 1 mile distant if water is available. Where the nature of the country and water supply will permit, when establishing camps place them about 1 mile in advance of construction to enable the crew to work both ways from them.

58. The ordinary sanitary requirements of the Forest Service will be observed in all trail camps.

CLEARING.

59. Clear to a sufficient width and height to provide unobstructed passage of loaded pack animals and horsemen, even when the brush is loaded down with snow. A rough rule of thumb generally applicable, but not always so, is to remove obstacles from either side within reach of the extended arms of a man standing at the approximate center of the tread or point of travel. Overhead clearing 10 feet from trail bed is the general working average required. Cut large trees only where to locate the trail around them is impracticable. Keep always in mind the point of view of a forester as well as a trail builder.

60. Cut trees and brush as close to the ground as is practicable without unduly increasing the cost.

61. Do not blast stumps in advance of grading. Stumps at top of back slopes should seldom be blasted out. Never blast stumps located at outer edge of tread. Cut interfering roots, but leave the stump to serve as a support to the trail. (Fig. 4.)

Don't blast trees at this point, swing
around large trees if practicable.
If necessary to remove them
cut here and thus. Blast only in case
of last resort.

To blast stump at points shown
always causes more work and poorer trail.

Don't blast trees at this point.
If large swing around them, or if
they are cut here, leave stump
in place to act as support
for the trail.

Side hill around
line

Form of trail when
grading is finished.

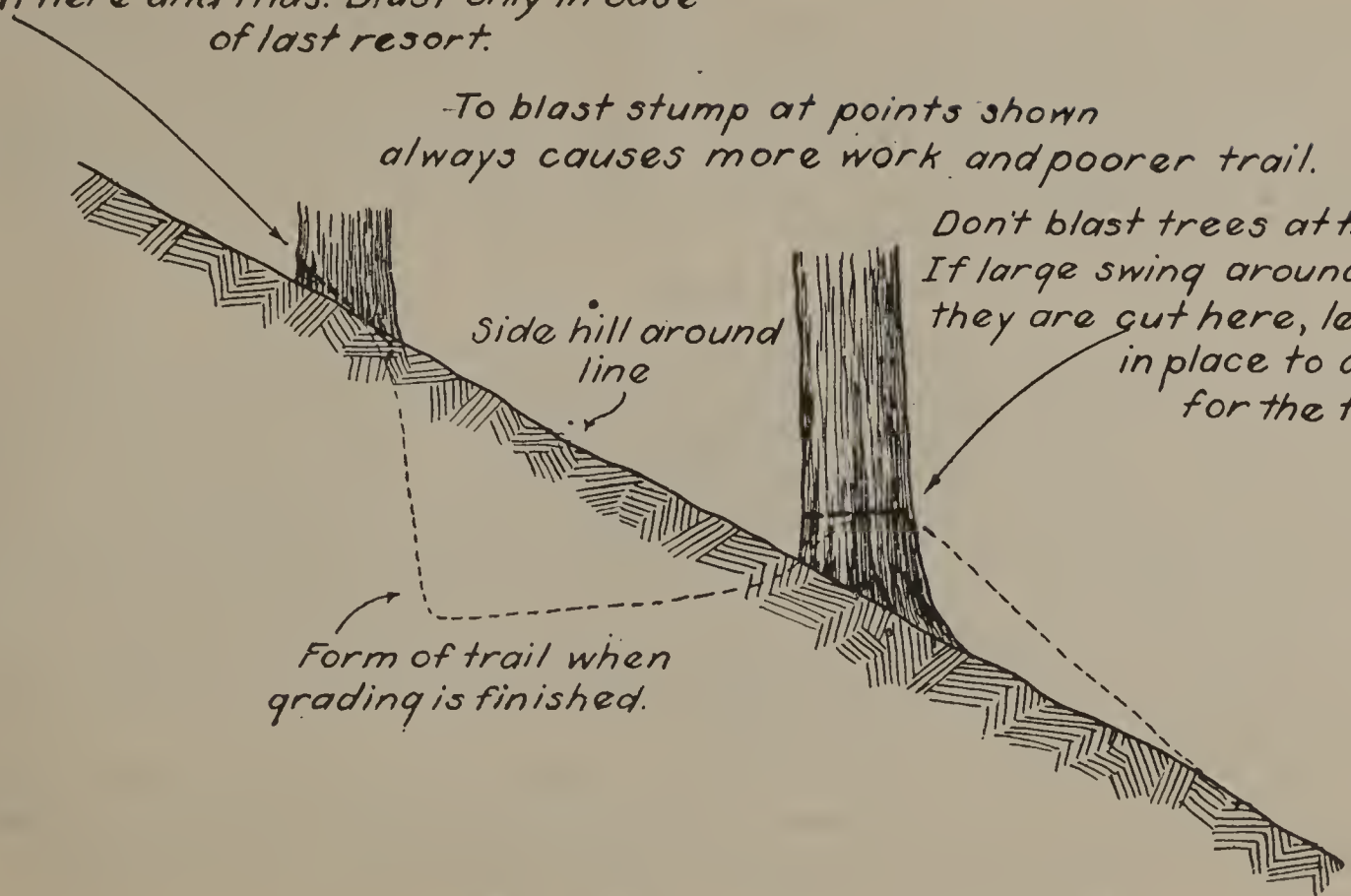


FIG. 4.—When not to remove stumps. (Par. 61.)

62. In clearing right of way always fall timber down hill, where possible, and throw brush down hill if it is not to be burned.

BRUSH DISPOSAL.

63. Pile and burn brush, limbs, and tops under 4 inches in diameter on projects to be used largely by the general public, if in accordance with the prevailing timber sale practice. Wherever safe, burn at the time of clearing.

64. On projects in more isolated regions to be little used by the public, dispose of the débris by lopping and throwing it down hill, or by roughly piling it beside the trail on level or nearly level locations; however, where the district forester considers it sound practice to dispose of brush completely, pile and burn it. Brush should not be piled and burned merely for the sake of the brush-burning principle.

WIDTH OF TRAIL.

65. Width of trail means the distance from the inside edge of the trail to the outside edge. (Fig. 5.)

66. Table 2 and Figures 6 to 9 indicate specifications and designs applicable under varying slopes. Conform primary trail construction to them. They are standards for primary trails. (See Par. 67.) Exception may be made only (a) where a ditch is necessary to carry off seepage from springs (see Fig. 20); (b) on certain recreation trails where the district forester can justify the construction of wider trails than described in the specifications and diagrams. To warrant any exception, a showing must be made in every case that the exception is justified by some inescapable demand rather than upon a forest officer's interpretation or opinion of what the recreationists want or need in the way of trails. Under normal conditions and circumstances trails built upon the specifications for primary trails are adequate for all purposes, including recreational use. Forest officers should educate the public in good trail economics and will never encourage extravagant ideas in trail construction.

67. It is recognized that completed secondary trails on steep slopes and rough ground may approach the standards of width and finish of primary trails, but should seldom equal and never exceed them. Always confine work on secondary trails to that which is just necessary to furnish reasonably easy and safe passage and no more.

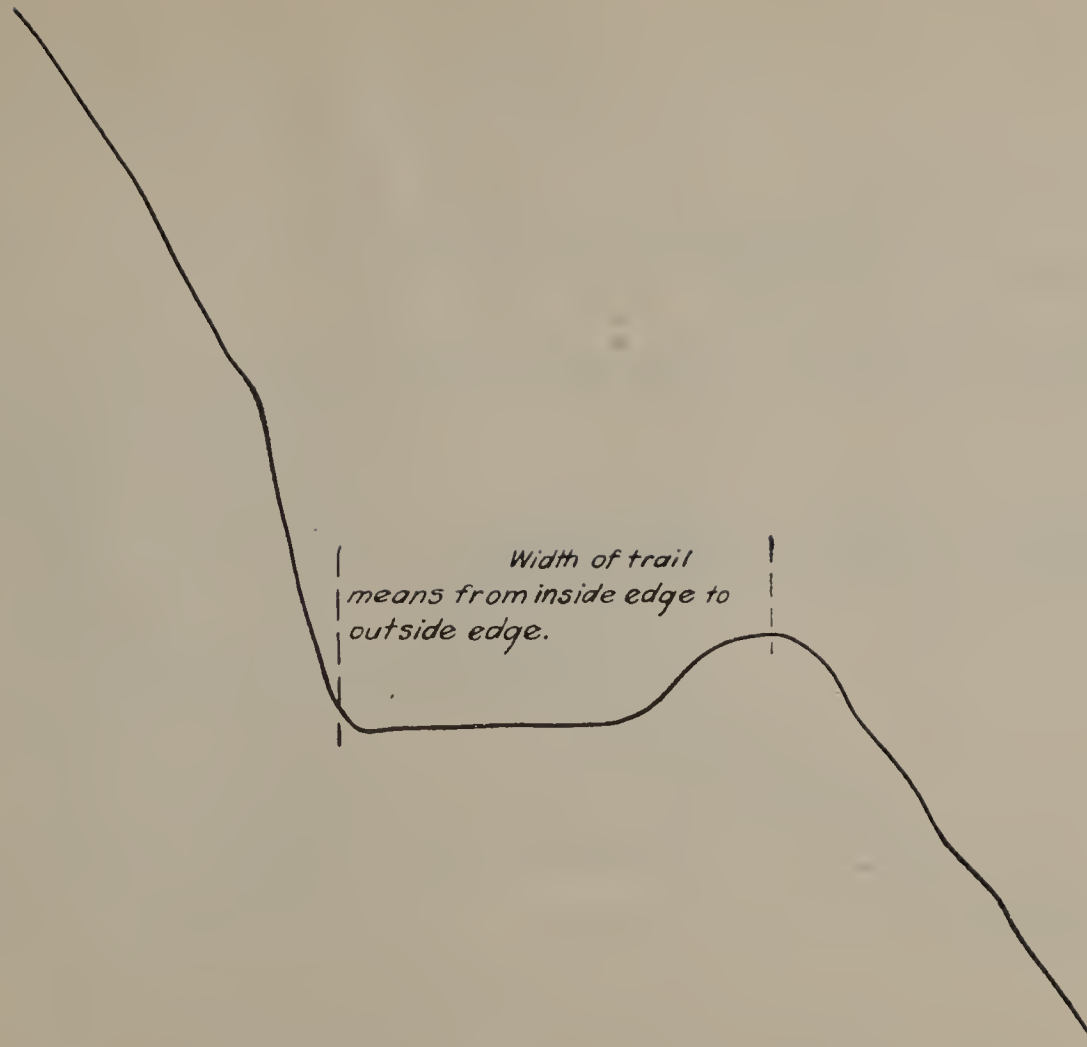


FIG. 5.—How to measure width of trail. (Par. 65.)

WIDTH.

TABLE 2.

Class of trail.	Side slopes.		Width over all (inches).	Notes.
	Percentage.	Corresponding degree of slope.		
Primary.....	0 to 30.....	0 to 17.....	None.....	Simply mark with an appropriate tool a narrow line to indicate the proposed line of travel if land is smooth. If rock or stumps or roots occur remove them to a total width of 18 or 20 inches. If rock in place forms an obstruction aim to remove it to a maximum width of 24 inches.
Do.....	31 to 85.....	18 to 40.....	24 maximum.....	Over all from bank to bank.
Do.....	85 to 165.....	41 to 60.....	24 to 30 maximum.....	On the steeper slopes rock in place will frequently be found.
Do.....	Over 165.....	Over 60.....	30 to 36 maximum.....	The character of rock will often influence width to some extent. Width in close grain rock is controllable. Seamy rock will break to seams; therefore, width will be uneven. In no case intentionally blast more rock than just necessary to get the specified width.
Secondary ¹	0 to 50.....	27.....	None.....	Simply mark a narrow line to indicate the proposed line of travel. If stumps, rocks, and roots occur remove them only to a width sufficient to provide free passage and never in excess of 24 inches.
Do.....	50 to 85.....	27 to 40.....	24 maximum.....	Any width to a maximum of 24 inches, which will make passage reasonably easy and safe.
Do.....	85 to 165.....	40 to 60.....	30 maximum.....	Any width up to a maximum of 30 inches which will make passage reasonably easy and safe.
Do.....	Over 165.....	Over 60.....	36 maximum.....	Any width up to a maximum of 36 inches, which will make passage reasonably easy and safe.

¹ Foot trails may be made much narrower and may often consist merely of a blazed way cleared of brush.

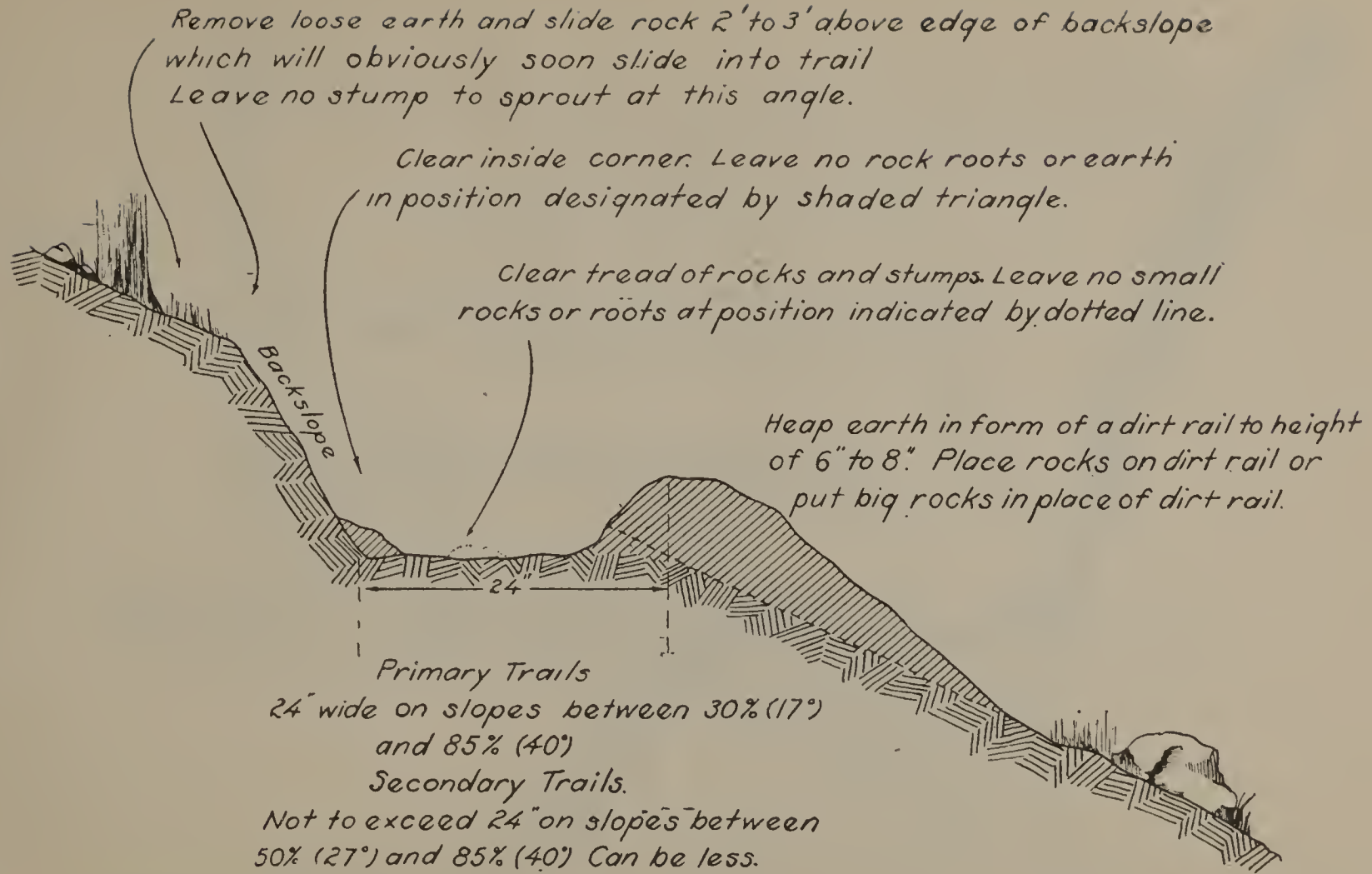


FIG. 6.—Cross section of typical trail in earth or shale rock on slopes between 30 per cent (17°) and 85 per cent (40°). (Par. 66.)

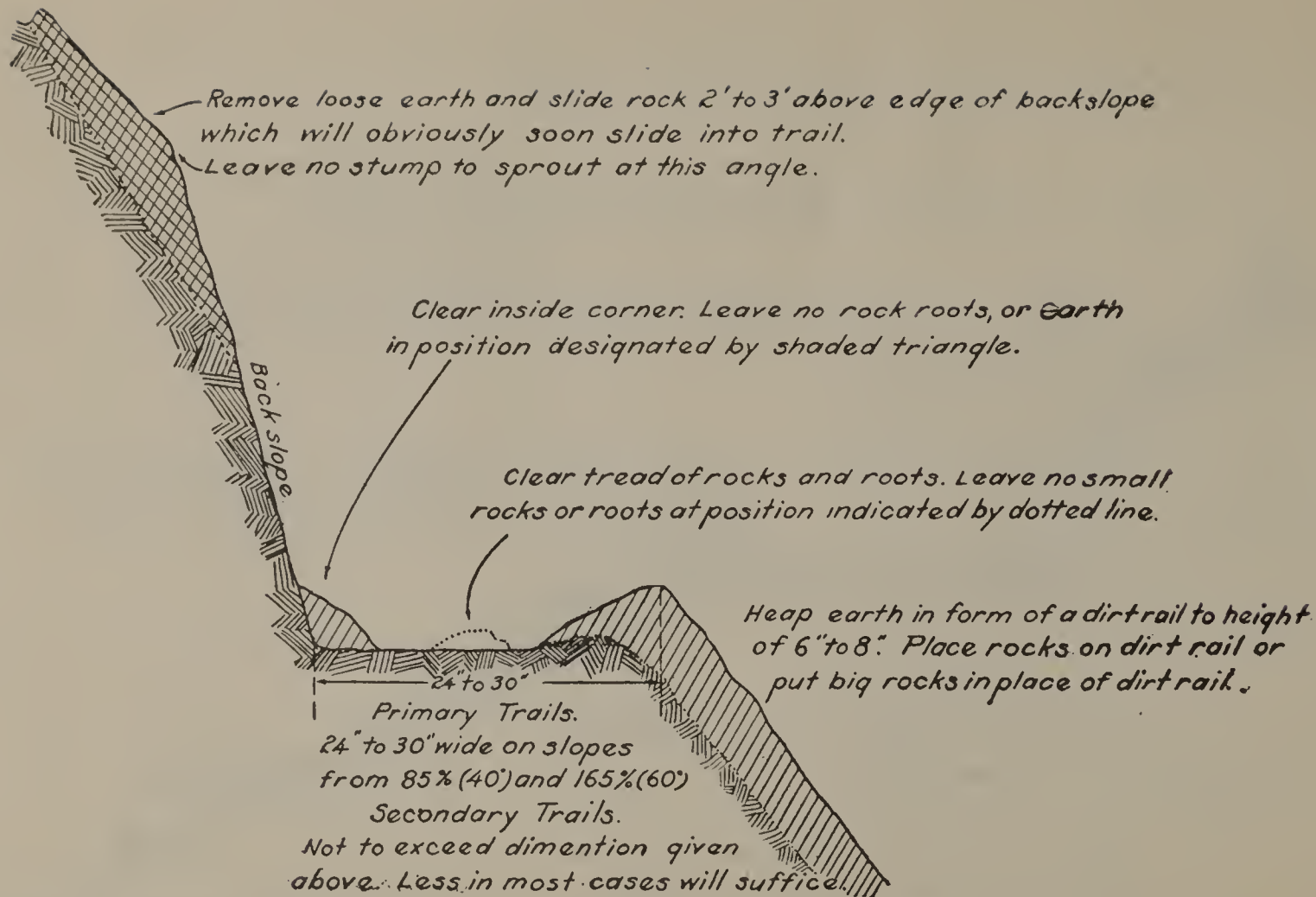


FIG. 7.—Cross section of typical trail in earth or shale rock on slopes between 85 per cent (40°) and 185 per cent (60°). See exception illustrated in Figure 9. (Par. 66.)

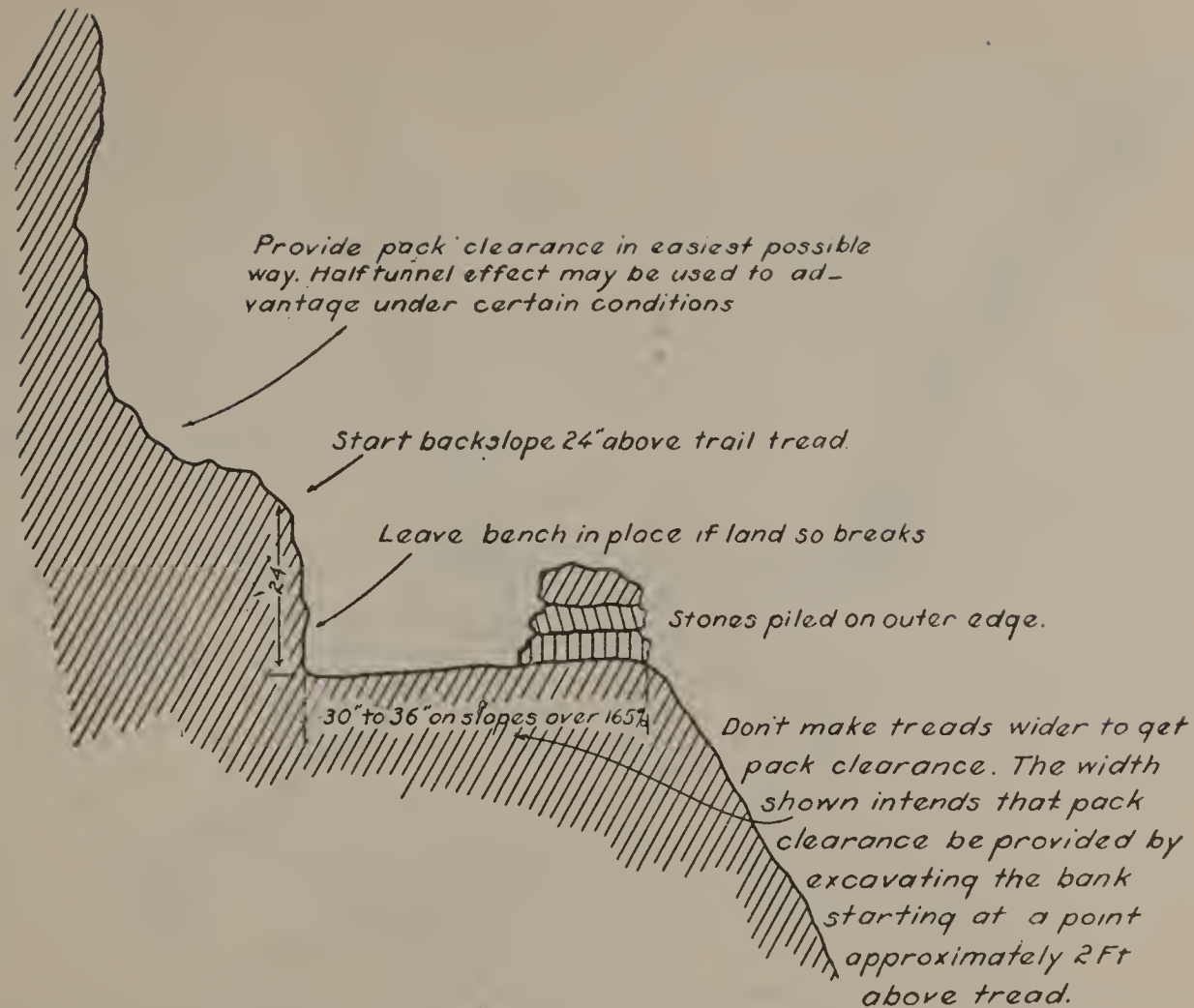


FIG. 8.—Trail construction on steep hard slopes and around bluffs. (Par. 66.)

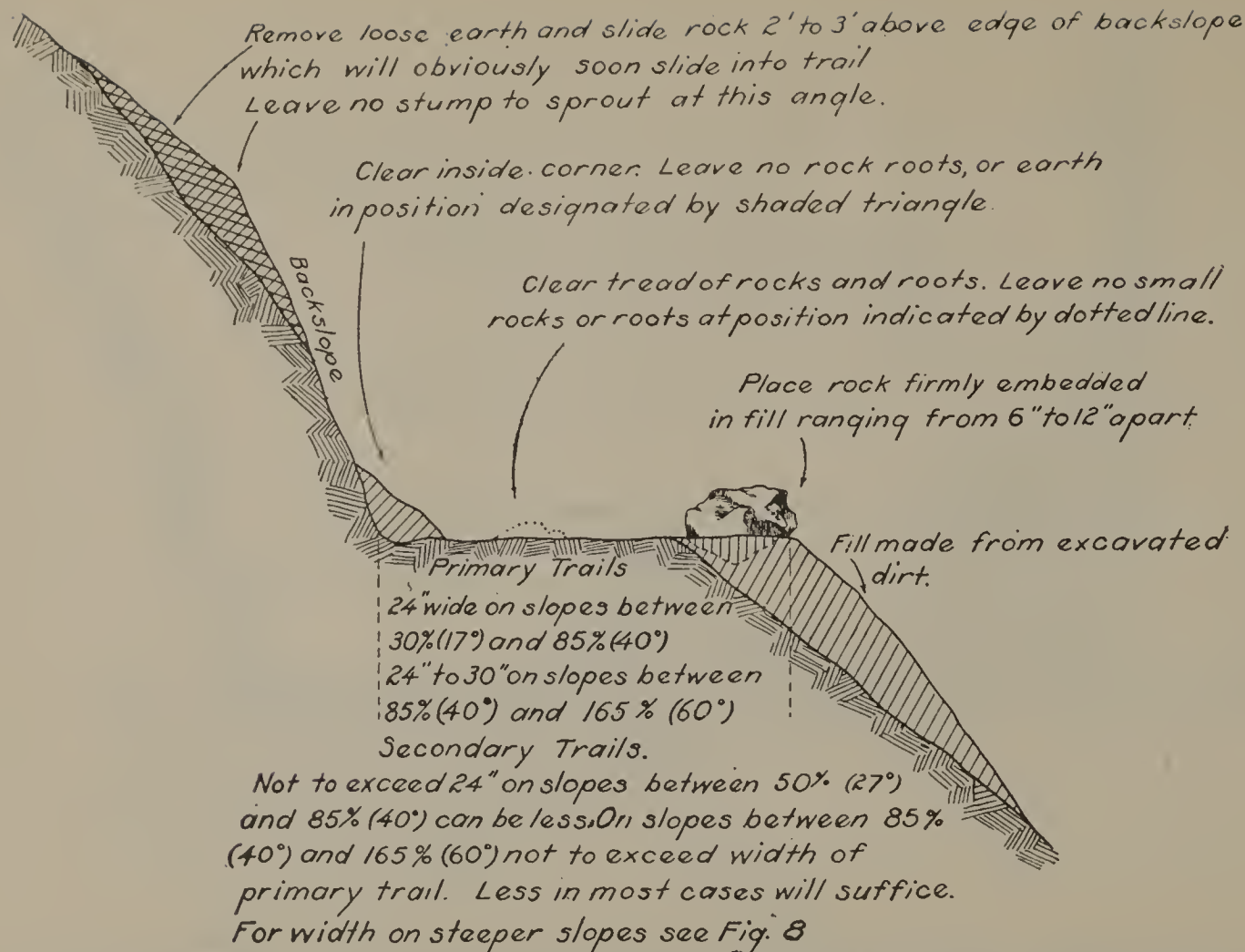
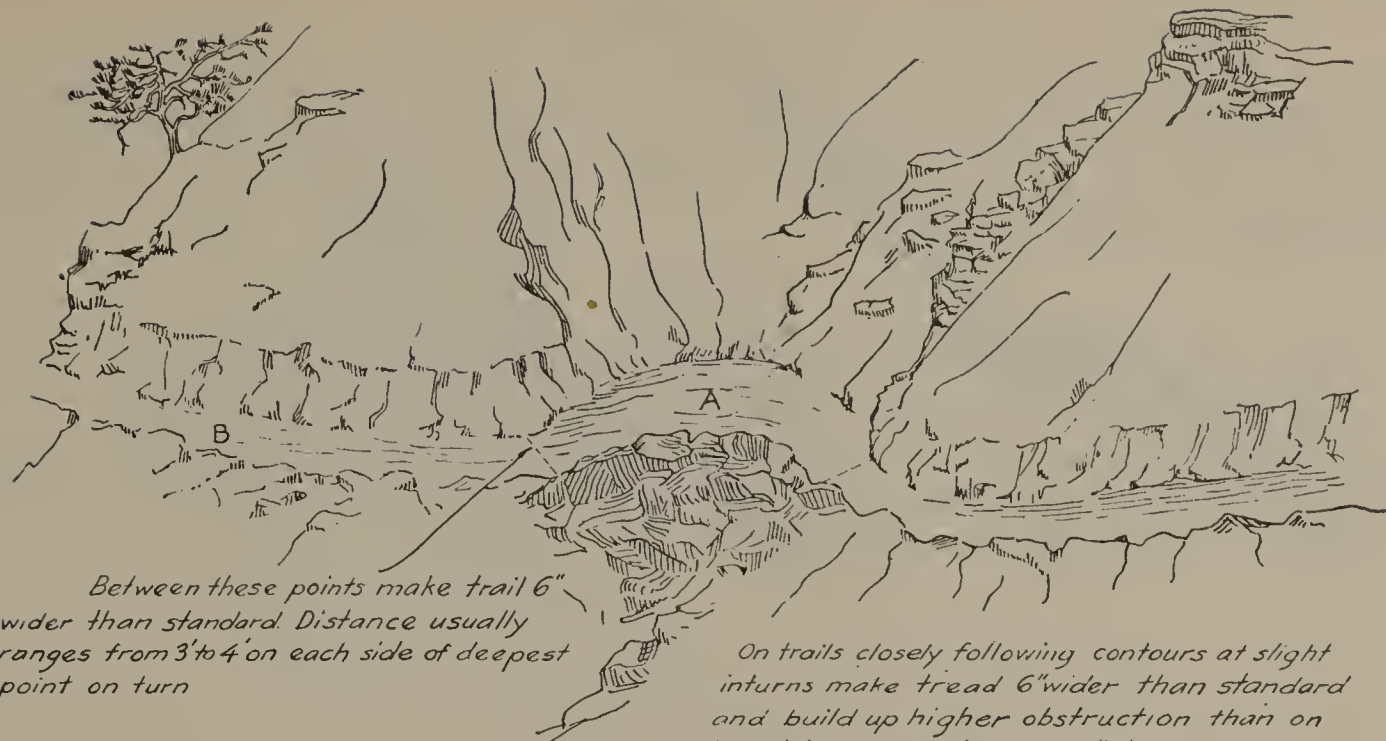


FIG. 9.—Cross section of the type of trail that might be constructed instead of that illustrated in Figures 6 and 7 in regions where cloudbursts and extremely heavy downpour of rain occurs as in district 3 and southern California. (Par. 66.)



Between these points make trail 6" wider than standard. Distance usually ranges from 3' to 4' on each side of deepest point on turn

On trails closely following contours at slight inturns make tread 6" wider than standard and build up higher obstruction than on straight away sections of dirt or rock to prevent cross cutting.

Augment inslope and out side rail.



FIG. 10.—This type of construction not applicable in Southwest nor to secondary trails.

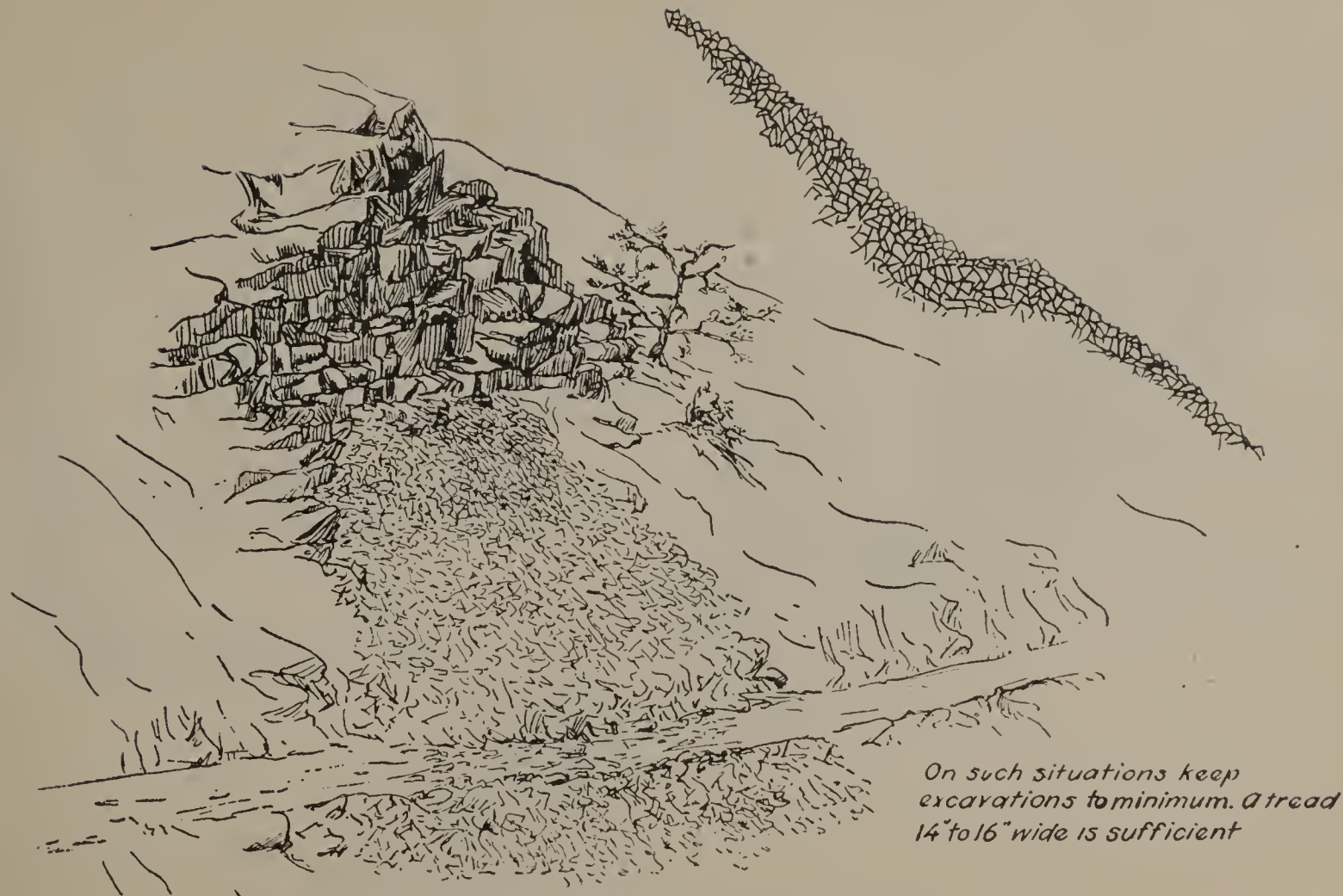
ROCK SLIDES.

68. In building either class of trail across rubble slides remove only sufficient material to provide good footing for an animal. Do not attempt to make a nice looking job. To do so may mean the making of a deep cut which, if the rock is small, seriously disturbs the equilibrium of the material. This frequently leads to never-ending obstruction and continuous maintenance. (Figs. 11-12.)

TURNOUTS.

69. Along very steep slopes, under certain circumstances of use, it might be necessary to improve natural turnouts at intervals. Such places are most commonly found on points, or in gullies or ravines.

70. Short, rough treads above or below the regular one might be made to provide passing places for pack trains or other forms of heavy travel on long stretches of abrupt slopes lacking in natural turnouts. Confine work on passing trails to the minimum; merely make a passing place safe.



On such situations keep excavations to minimum. A tread 14" to 16" wide is sufficient

FIG. 11.—Trail on rubble consisting of small rocks. (Par. 68.)

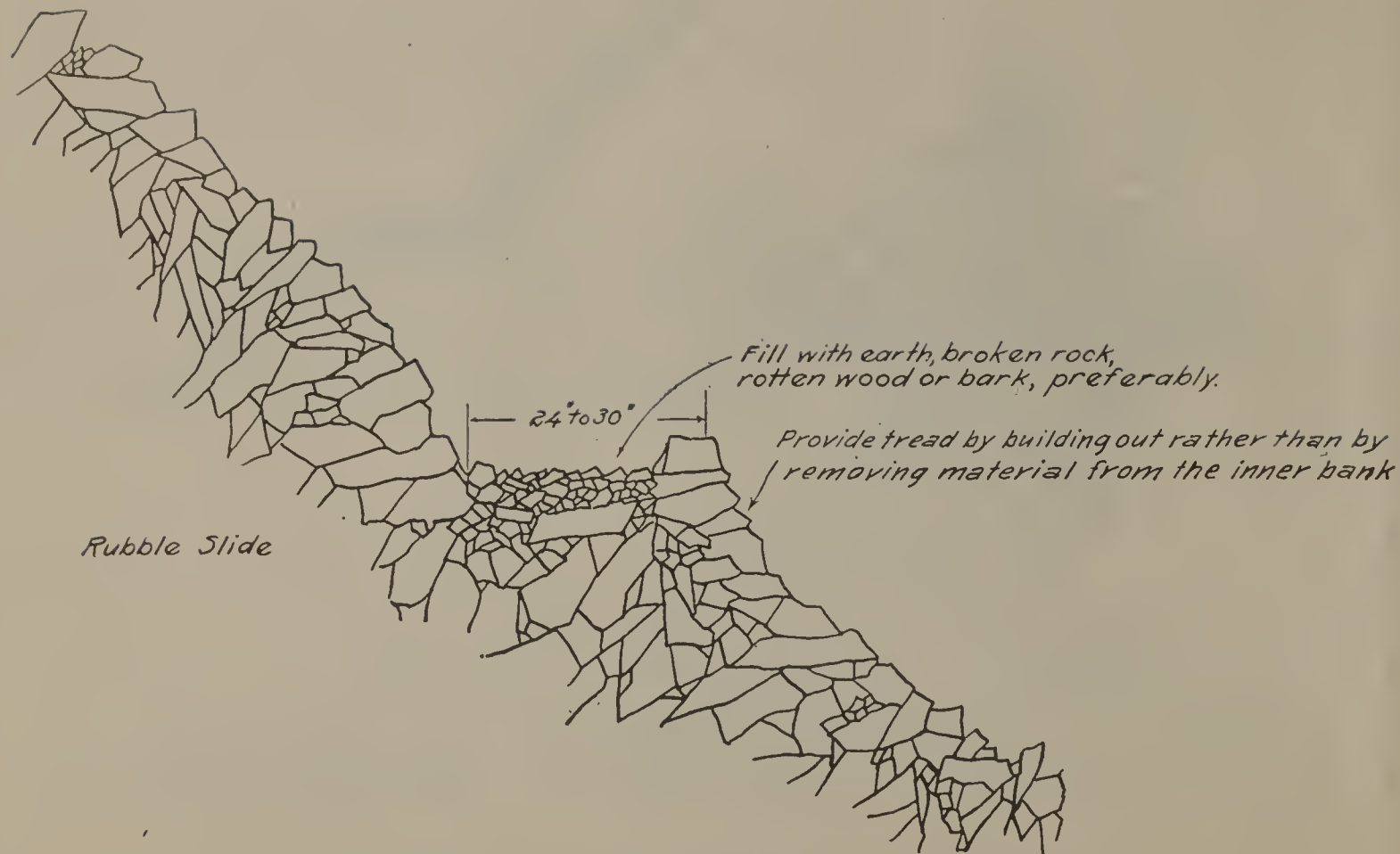
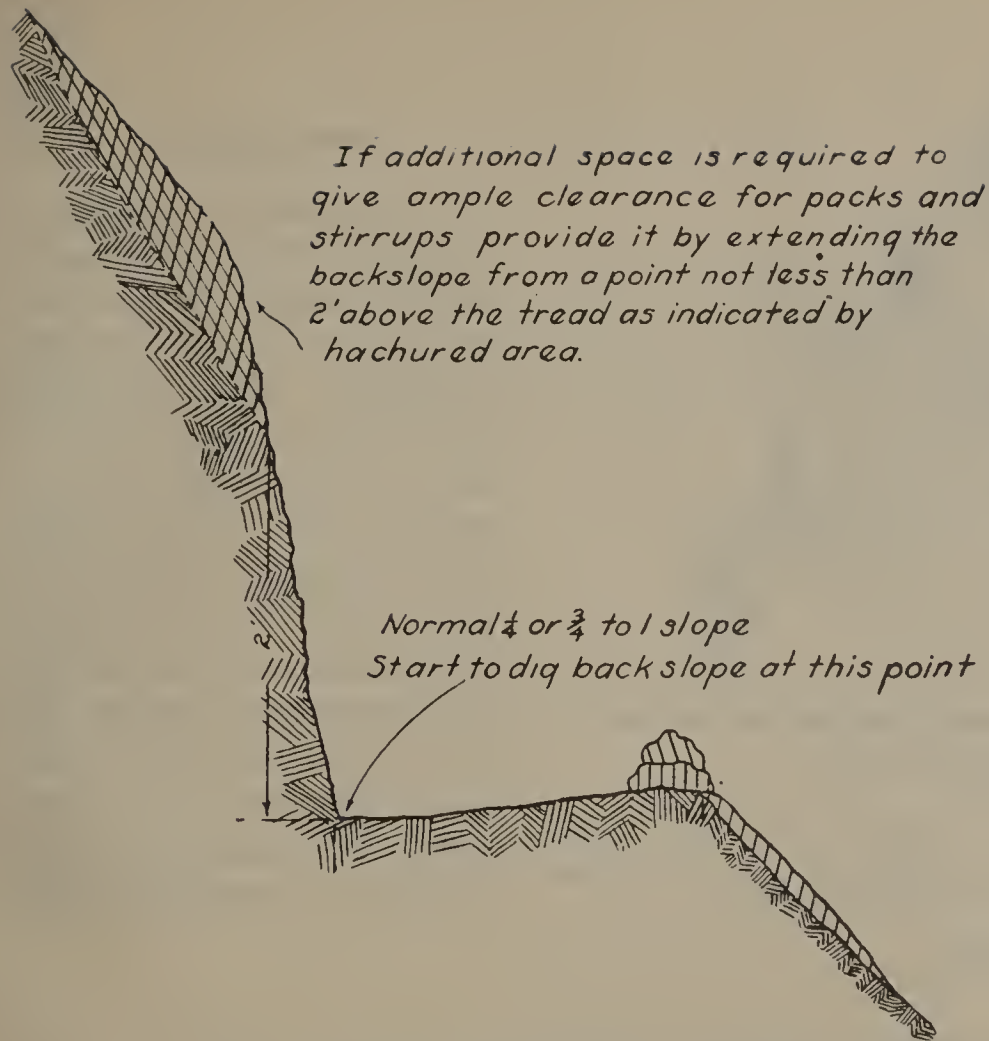


FIG. 12.—Trail on rubble consisting of large rocks. (Par. 68.)



BACK SLOPES.

71. In earth, start back slopes from inside edge of tread. Give sufficient pitch to the back slopes to bring the earth to angle of repose. If packs or stirrups will not then clear, provide ample room by removing more earth from the bank at the position designated in Figure 13. These instructions apply to both primary and secondary trails.

72. Back slopes and clean clear space in solid rock will be got in easiest possible way. (See Fig. 8.)

FIG. 13.—Showing most economical method of providing clearance for pack and stirrup on slopes. (Par. 71.)

SWITCHBACKS.

73. Reference Caption (l), Paragraph 34, and Figures 14 and 15. Either the guard rail or methods shown in Figure 15 may be used to prevent crosscutting at turns of switchbacks. Use one of them unless the turn is made in solid rock or around a big tree or large rock. The instruction of this paragraph applies only to primary trails which will be heavily traveled by animals. The guard rail or guard wall will seldom if ever be required on secondary trails.

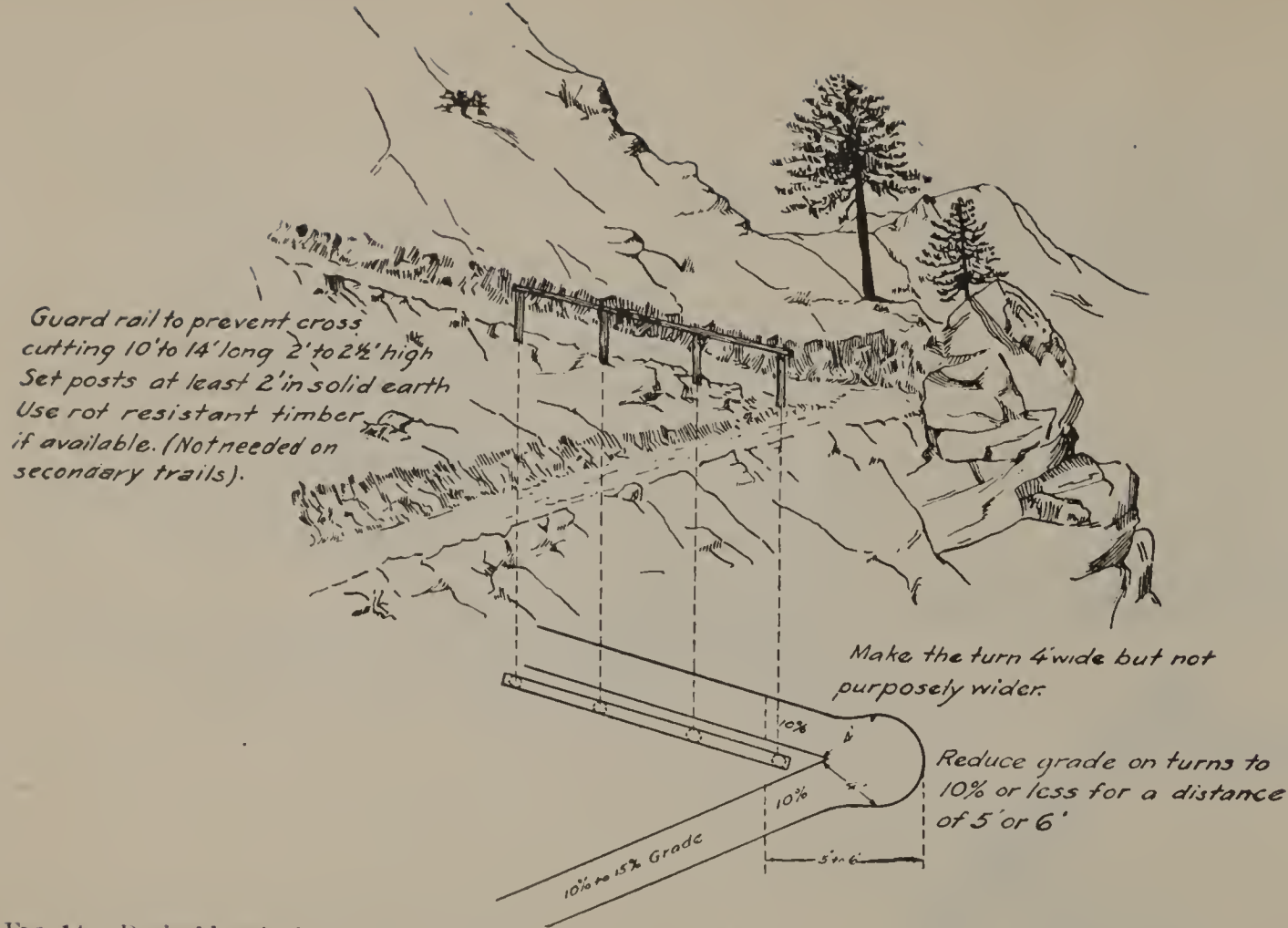


FIG. 14.—Desirable width of turn, the reduction of gradient and the guard rail on switchbacks. (Par. 73.)

Rock wall well set 10' to 14'
long and 6" to 10" higher than the
bed of the trail to prevent cross cutting.
At point of the turn and from it back
3' or 4' make the wall 18" to 24" high



Fig. 15 Showing use of rock wall to prevent cross cutting at turns of switch backs.
Use only where rock of substantial sizes are handy. (Not needed on secondary trails).

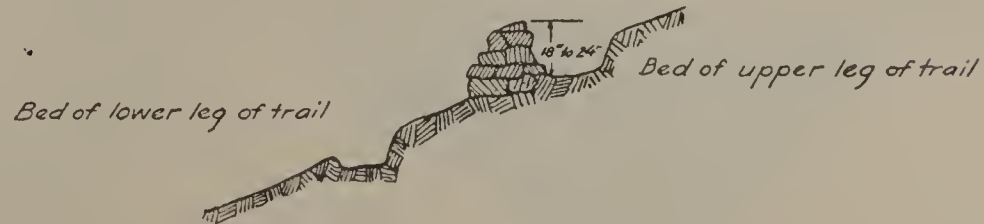


Fig. 15a. Cross section 10' ahead of turn showing use of dirt rail or cut 18" to 24"
deep and rocks on outer embankment to prevent cross cutting on switch back

(Par. 73.)

ROCK WALLS.

74. Use rock walls only where to construct them is cheaper than blasting to secure a tread in solid, or where impossible to make tread in solid. (Figs. 16-19.)

75. In wall construction, first prepare a foundation on solid earth or rock, pitching in from 2 to 3 inches to each foot of elevation.

76. Use only sound, durable and well-shaped rocks. Ordinarily, use no stone less than 3 inches thick nor less than three-quarters of a cubic foot in volume in the body of the wall. Use of smaller stones for chinking is permissible.

77. See to it that—

(a) At least one-fourth of the front and rear face of the wall is composed of headers having a length at least two and a half times the thickness.

(b) All projecting points are removed from top and bottom of main rocks and that each is laid with good bearing on its broadest face.

(c) All headers are laid with their greatest dimension extending into the wall and never parallel to it.

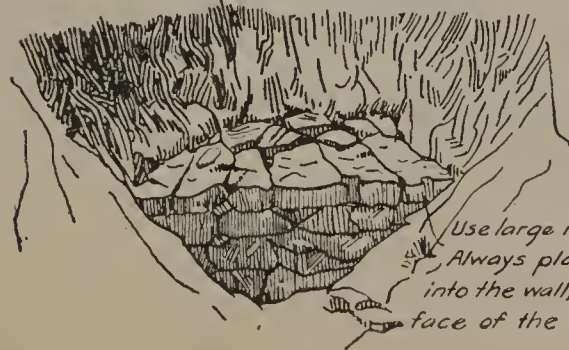
(d) All walls have a batter or a slope inward of at least 2 inches to each foot of height.

(e) Avoid, with no exception, the common practice of laying up a face course of any kind of rock and filling in behind it with small rocks and dirt as the wall goes up. It will surely collapse sooner or later. A durable wall must have a front and rear face well tied together with good big header stones.



Fig. 16 Showing a typical unavoidable depression requiring a rock wall
Don't use poles to span such a place if rock is at hand

Fig. 17 Showing face and intermediate layer of rocks in a correctly layed rock wall.



Use large rock for headers
Always place long narrow stones
into the wall, never parallel to the
face of the wall.

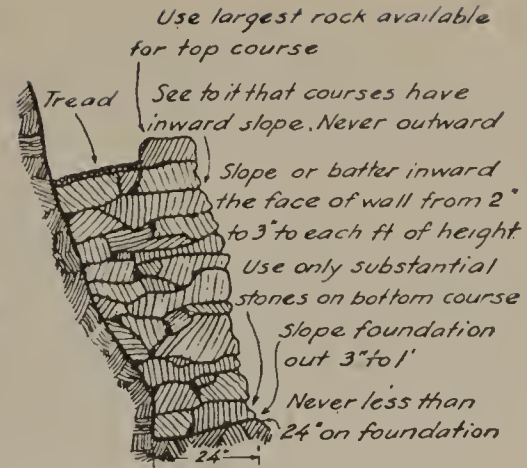


Fig. 18 Showing cross section of a
correctly layed rock wall.

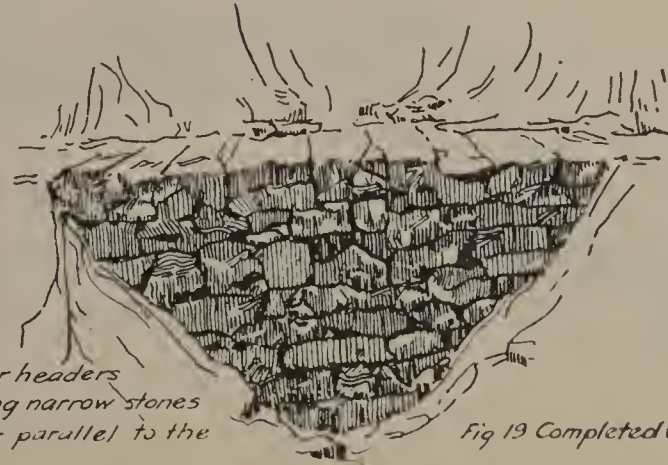


Fig. 19 Completed wall

DRAINAGE.

78. Drainage structures will take three forms:

Form 1. Open ditches (Fig. 20) for seepage.

Form 2. Water bars (Figs. 21 and 22) to turn seepage and run-off of rains and snow from the trail.

Form 3. Culverts.

OPEN DITCHES.

79. Use this form to drain seepage or run-off from numerous springs located above a trail. Lead water which collects in the ditch across the trail, if earth is solid, in open ditch or before a water bar. If the earth is soft use a culvert of large stones or one made of the most durable timber at hand. Never use this system to drain ordinary run-off from storms or melting snow. On very soft ground it may be necessary to corduroy the tread bordering the ditch. (Fig. 20.)

WATER BARS.

80. Install water bars coincidentally with grading. Permissible intervals between water bars will depend altogether upon the volume of run-off and character of soil. The question is one for local settlement. Where any are needed be certain that enough are used. Always slope the bar at an angle of 30° or more. On steepest grades place them at an angle of 45° .

81. To prevent erosion of the outer embankment, in selecting places for water bars and other forms of drainage, take advantage of natural obstructions such as trees, stumps, and roots or rock found on the lower side of the trail. Where soils are very loose, if natural obstructions are not available, it might be good practice in extreme cases to rip-rap the lower side of the trail with brush or rocks. (Figs. 21-23.)

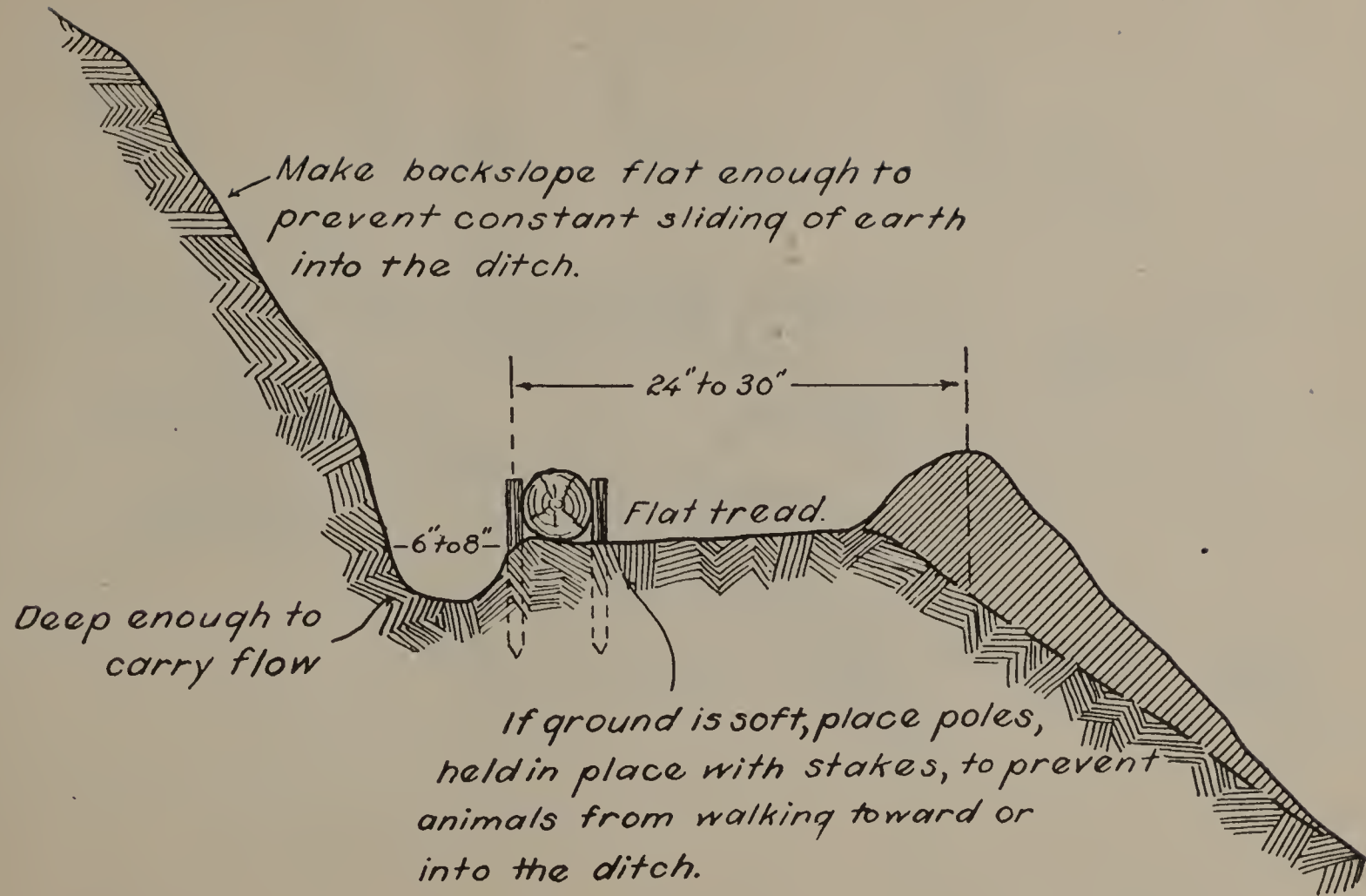


FIG. 20.—Cross section of a trail provided with a ditch against the back to drain seepage from springs above the trail. (Par. 79.)

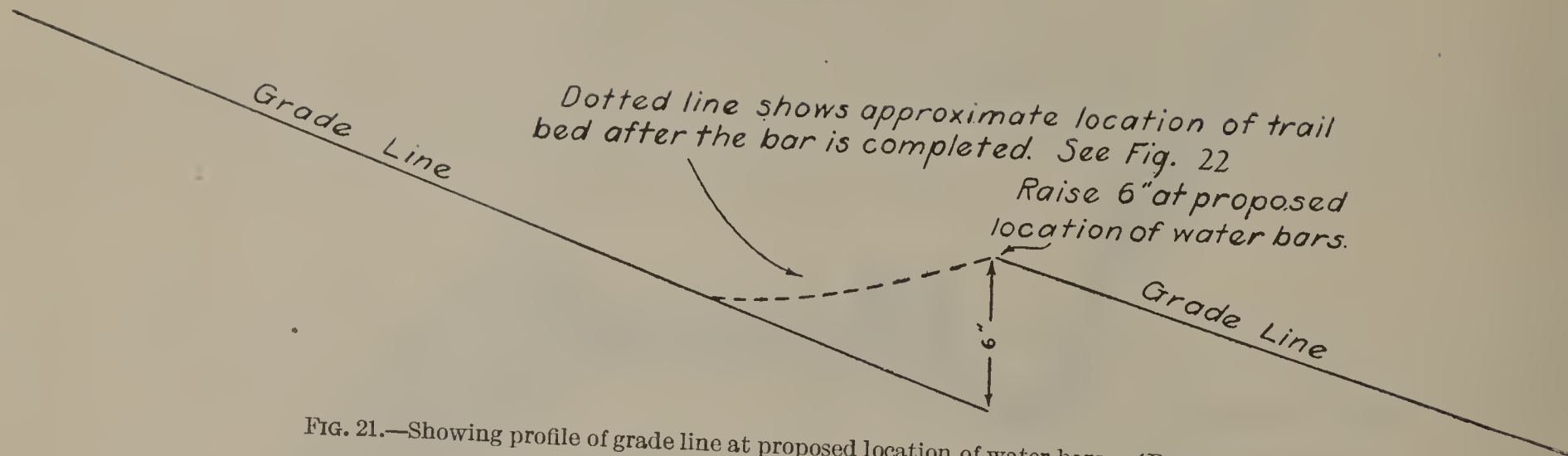


FIG. 21.—Showing profile of grade line at proposed location of water bars. (Par. 81.)

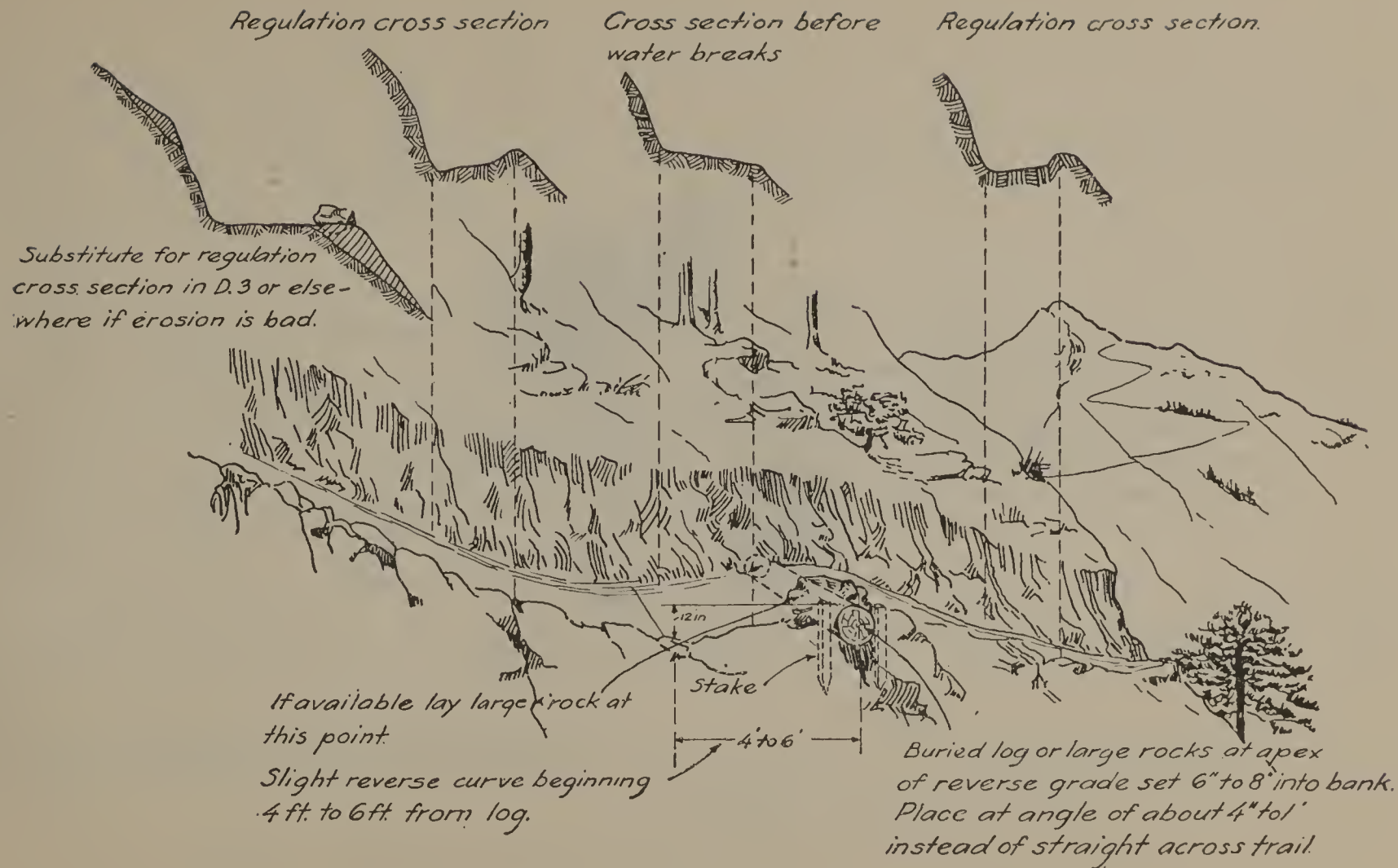
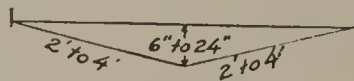


FIG. 22.—Lateral section of trail showing water-break log. (Par. 81.)

Where trails cross arroyos draws and ravines give the trail an up grade each way from the water course for a distance ranging between 2 to 4.



Detail of crossing of water courses



Dip of 6" to 24" depending upon amount of probable run off.

FIG. 23.—Showing method of preventing washouts at crossing of watercourses. (Par. 81.)

CULVERTS.

82. Use culvert only to cross more or less permanent water, where soft bottoms and boggy land on either side during the field season make travel difficult.

83. Do not try to fill boggy places with large rocks. It is bad practice, and the result is simply a place in which a horse may injure or break his leg.

CORDUROY.

84. Avoid boggy land to the fullest possible extent even if, to escape it, best topographical location of a trail must be sacrificed, the best grades abandoned, and length of a trail materially increased.

85. If impracticable to avoid swamps and bogs, first consider the possibility of making a dry tread by draining as illustrated in Figure 24. If that is not feasible, lay corduroy across such places.

86. Principles to be observed in all corduroy construction are (Figs. 25 and 26):

(a) Extend ends to solid ground.

(b) Use most durable timber available of substantial size.

(c) Remove the bark.

(d) Wherever practicable, place the entire structure, sills, stringers, and flooring below the mud line instead of placing it on sills which elevate the structure above the line of permanent moisture. This will prevent rot.

(e) Provide an adequate base of stringers, and add sills to prevent sagging and tipping of any section of the structure.

(f) Fasten flooring in place.

(g) Lay flooring crosswise unless wide piece of split material or poles over 8 inches in diameter can be obtained.

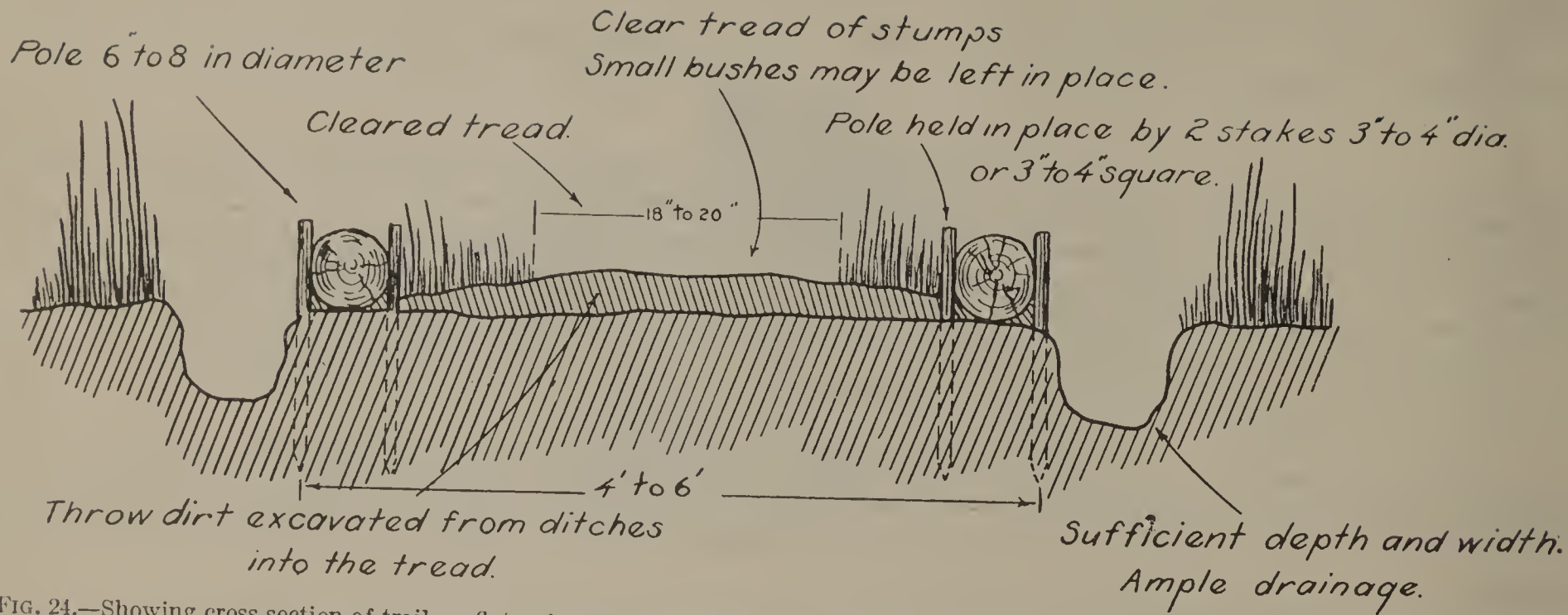


FIG. 24.—Showing cross section of trail on flat soft wet ground where ditch on each side will provide a dry and more durable tread than corduroy. (Par. 85.)

Do not use round material less than 8" in diameter
laid lengthwise nor split material less than 10" wide.

Place entire structure below the mud line if practicable

Split cedar or fir
Not less than 4" thick.

Spikes or tree nails 1" in diameter
Latter preferred

Flatten top of sill
to give good bearing.

Sill centers not further
apart than 4 or 5 ft.

Not less than
30" wide

30"

Sills not less than 6"
in diameter and $4\frac{1}{2}'$ long.

Sills where two sections
join not less than 8" in diameter

Cover with dirt.

Joint

Sills not less
than 6" in dia.

Drain

Sill not less
than 8" in dia.

Side view of split corduroy

FIG. 25.—Section of split corduroy.

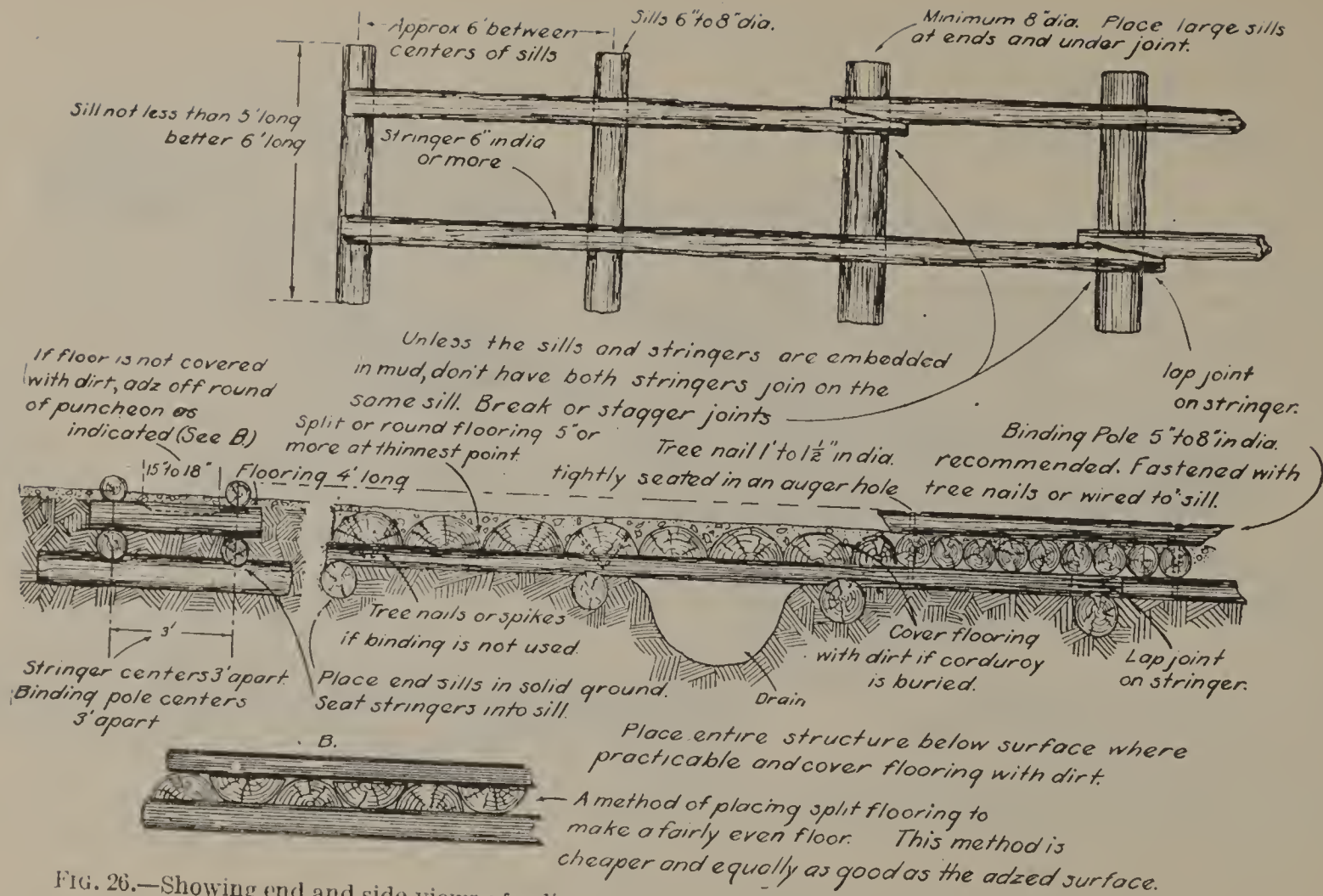


FIG. 26.—Showing end and side views of ordinary sill and stringer corduroy with puncheon or pole flooring.

FORDS.

87. Fords, in place of bridges, are to be favored where suitable ones can be located. The ideal ford is at a point where the stream widens out, with a slackening in velocity and a gravelly bottom. Carry grading to the water's edge so an animal will not drop off on one side and have to scramble out on the other. Wherever practicable rocky fords should, during low water, be improved by rolling out or blasting rocks from the tread and filling in with smaller rocks and gravel, or by rolling loosened rock to down stream side to restrain débris in form of sand and small rocks which in time will accumulate and make a good bottom. A log firmly fixed across smaller streams may sometimes be effectively used to form a barrier to hold débris.

MARKING.

BLAZING.

88. Place Forest Service trail blazes so that one from another they are visible to a traveler approaching in either direction. A greater amount of blazing is waste and must never be permitted. Blaze only as construction progresses. Blazes may be omitted on graded trails.

Do not use the Forest Service blaze promiscuously; as for example, to mark ways into temporary camps. Use temporary markers of cloth or paper or any other convenient means except blazing to designate location during reconnaissance.

89. Table 3 specifies a system of marking Forest Service trails. It applies to all existing trails not adequately marked and to all new construction.

TABLE 3.—*Marking systems.*

Location.	Character of markers in order of preference.
In timber.....	(1) Forest Service blazes on both sides of trees; optional on graded trails.
Across meadows and other openings over 600 feet across.....	(1) Posts, or posts and markers or stone monuments 300 feet apart (approximately). Blaze trees on both sides of the opening.
Both sides of fords.....	(1) Blazes on trees on both sides of trail; (2) posts, or posts and markers or monuments on both sides of the trail.
Above timber line.....	(1) Small rocks placed on larger ones commonly known as "ducks;" (2) monuments, 300 feet apart (approximately); (3) posts, or posts and markers.
All other places where a traveler may be in doubt.....	(1) Blazes; (2) posts, or posts and markers or stone monuments.



On thin-bark trees make a neat blaze, not a long ragged one resulting from a careless swipe of an ax. See to it that ax-men do not exceed dimensions given. Do not waste time making square corners. A stroke up, a stroke down, and the removal of the bark between, in the easiest possible manner, is the correct practice.

FIG. 27.—Trail blaze.



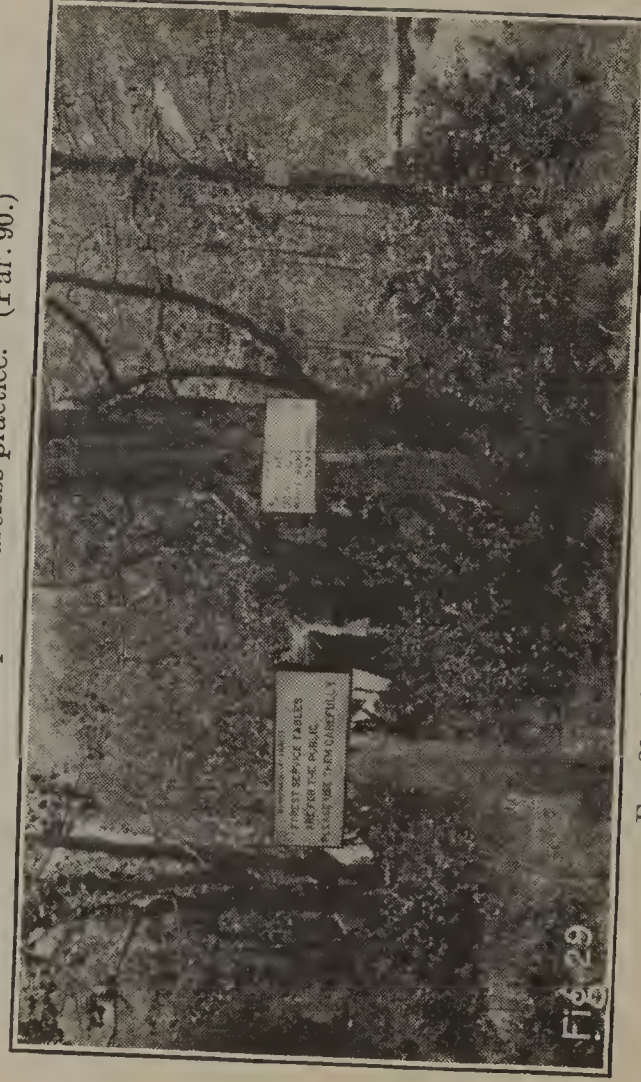
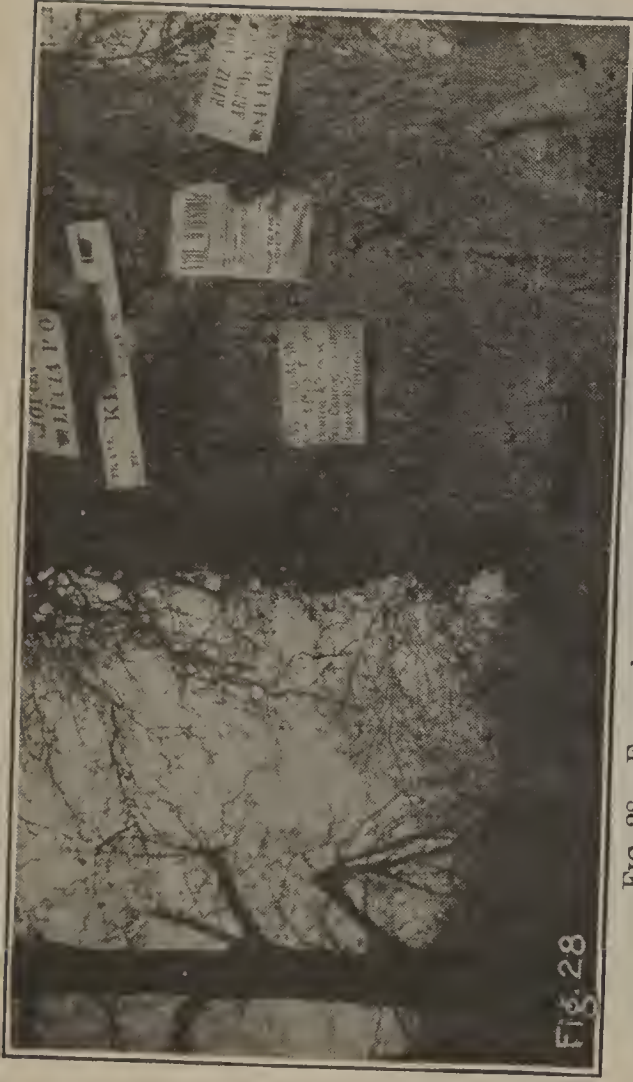
Cut no deeper into heavy bark trees than necessary to make clear blaze. Don't cut into sap, a clear blaze can be made otherwise. See to it that axe-men do not exceed dimension given.

Fig. 27a Trail blaze

SIGN POSTING.

90. The ultimate object is to have metal signs of standard design for the Service at all trail forks and intersections. (See Figs. 28 to 32.) Metal markers, "Trail," "Ford," etc., will also be used. Simple and inexpensive mile markers are desirable to have on main trail. Indicate position for mile signs as progress of construction is measured. Pending the time that this can be done, use temporary signs freely. The roughest sign lettered with charcoal, pencil, or crayon is better than none. Use them liberally if more durable or sightly signs are not soon obtainable.

91. Put all the better types of signs on correctly located large trees wherever possible and never on a limber or crooked sapling, tree, or bush. Do not place signs on poorly located trees, such as trees out of line or ones bordering the trail, but 50 or more feet ahead or back of an intersection of two trails. If suitable trees correctly located are not found, use substantial posts of the most durable timber at hand, peeled, and well set. Place signs never lower than 5 feet, and, as a rule, not more than 6 feet above the ground. In regions of heavy snowfall, or in localities where damage by cattle is probable, heights up to 7 feet are approved. Metal signs should always be backed with boards and attached with screws, preferably blued screws, never with nails. The instructions on the mechanical features of sign posting may be summed up by saying "Give sign posting the stamp of good workmanship."



Post For Sign Board.



Fig. 31



Fig. 32 Method of setting posts for signs where impracticable to set in hole.

MISCELLANEOUS PRACTICES.

92. The following suggestions are worth the study of all users of this handbook:

PRACTICE.

Good.	Bad.
<ol style="list-style-type: none"> 1. To use bits of rags or paper, or any other mark easily obliterated, to mark preliminary location lines. 2. To start to dig tread from the grade line. 3. To use the undercut method of digging. 4. To have grader stand on the lower side of the grade line in order that he can draw the dirt outward and shape the dirt rail without the need for a shovel. 5. To use shovels sparingly on the average trail job. 6. To have the foreman designate sections 25 feet to 50 feet long for each man, to prevent bunching of men. 7. To have the foreman equipped with a measuring stick to check up width of tread. 8. To use "single jacks" on drills in soft rock. 9. To use 40 per cent nitroglycerin powder if TNT is not obtainable for rock work. 10. To use 20 per cent nitroglycerin powder if TNT is not available for stumping. 11. To study the comparative cost in time and material in use of explosives as against labor for the doing of a given job. 12. To do all blasting just in advance of noon or evening quitting time whenever practicable. 13. To have at least one wheelbarrow on every primary trail job. 14. To have plenty of tools and to have sharp ones in the hands of every man who uses an edged or pointed tool. 15. To make camps comfortable for men. 16. To serve good, substantial food, and to go light on fancy stuff. 17. To have cooks carry hot food to men on the job rather than serve cold lunches or to walk men long distances to dinner. 18. To treat men fairly and to expect and get a full day's work from everyone. 19. To discharge promptly those who do not give a full day's work. 20. To discharge promptly the chronic "kicker". 	<ol style="list-style-type: none"> 1. To blaze out preliminary location lines. 2. To start to dig tread from a point above the grade line. 5. To dig trails so wide that the use of shovel becomes necessary. 6. To permit mattoek men or swampers to select places to start work. 7. To make trails wider in good ground than on rough, steep places simply because it is easy and nice to do. 11. To follow recklessly the notion that use of explosives is cheaper than labor in the removal of small stumps and logs. 12. Blasting at any time the rock men or powder men might have holes ready to shoot. 14. To permit men to work with dull tools. 15. To use poles covered with dirt to span depressions unless very rot-resistant material is available. 16. To use nondurable poles under fill as a support.

PRACTICE.

Good.	Bad.
<i>21. To measure carefully each week the amount of trail completed and to check cost of the output.</i>	
<i>22. To mark mile points as construction work progresses.</i>	

PRACTICE.

Good.

Bad.

PRACTICE.

Good.

Bad.

MAINTENANCE.

POLICY.

93. The maintenance policy is stated in paragraphs 2 and 11. In directing and supervising maintenance of trails, first fix the policy well in mind and then give the necessary attention on the ground to assure compliance with the spirit of the policy and the details outlined in this chapter. It is to be remembered always that construction work should proceed only as rapidly as well-balanced maintenance work can be kept apace. To build more trails than can be properly kept up is, as a general rule, both wasteful and foolish.

CLASSIFICATION.

94. Maintenance is classified under three general headings—"Emergency maintenance," "Ordinary maintenance," and "Extraordinary maintenance."

EMERGENCY MAINTENANCE includes all work that must be done to make trails simply passable before the fire season opens or before the regular crews complete the repair of a given trail.

ORDINARY MAINTENANCE has first call upon available funds, following emergency maintenance. It will be done currently and ordinarily includes:

- (a) Routine work of clearing trails of all logs and interfering brush.
- (b) Clearing tread of small slides and débris from the inside of the tread and light repair of treads.
- (c) Upkeep of drainage systems.
- (d) Repairing washouts.
- (e) Light repair of bridges, culverts, and corduroys.
- (f) Upkeep of trail markers and signs.

(g) Improving grades on steep broad-faced ridges.

(h) Removing rocks and roots from treads to make feasible the use of plows and scrapers in removal of the *débris*.

EXTRAORDINARY MAINTENANCE is given high priority—usually ahead of new projects in trail work plans. It comprises:

(a) Removal of dense growth of brush and trees.

(b) Removal of heavy downfalls of timber over considerable distances.

(c) Removal of heavy slides or reconstructing new sections of trails around slides.

(d) Replacement of cribbing preferably by rock walls and rebuilding of damaged rock walls.

(e) Regrading of tread at proper position where it has worn down hill.

(f) Making dangerous places safe.

(g) Relocating and constructing new sections where mistakes in original location materially reduces average rate of travel over the project as a whole or where the original trail is so badly damaged that reconstruction is necessary.

(Refer Par. 97).

(h) Replacement of unsafe bridges, culverts, and corduroys.

(i) Providing drainage which entails a large amount of work.

(j) Replacement of trail markers in considerable numbers.

(k) Removing rocks and roots from treads to make use of plows and scrapers feasible in removal of *débris*.

DANGEROUS PLACES.

95. Confine work under (f), extraordinary maintenance, to the elimination of actually dangerous sections, such as places with beds of slick rock on steep slopes, very rough trail beds bordering precipices, trails in boggy ground and where insufficient side clearance makes travel unsafe. Remember that conditions classed as dangerous in one locality may be merely relatively and not actually so; the same conditions might be accepted elsewhere as satisfactory without thought of need for improvement.

RELOCATING.

96. Confine work on graded sections as described under (g), extraordinary maintenance, to those where rate of travel has proved to be actually and materially slower than the average of the project. (Refer Pars. 13 and 36.)

97. Do not cut out pitches merely for the sake of making a section of trail look better, as, for example, the elimination of the reverse grade indicated in Figure 33, by the construction of a 10 per cent grade (shown by dotted line) simply because the 10 per cent grade should have been built in the first instance. However, if the section of a trail, as, for example, the section shown between *a* and *b* in Figure 34, is badly overgrown, its tread worn out, and the cost of reconditioning it would equal the expense of constructing a new section along the 10 per cent gradient, follow the latter plan. (Figs. 33-34.)

IMPROVING GRADES ON BROAD RIDGES.

98. In brushing out old ungraded trails which follow ridges or points, having broad faces, abandon the old route and cut a new clearing through on lower percentages of grades if the old trail is unreasonably steep and there is room to switch back. In the relocation, follow the principles outlined in paragraph 13. (Fig. 35.)

REMOVAL OF OBSTACLES FROM THE TREAD.

99. In maintenance work always remove all roots, stumps, and projecting rock in the bed of the trail which, if not dug out, would interfere with efficient use of plow and scraper. Give particular attention to the making of a clear-cut angle at the meeting of the back slope and the tread. (Figs. 6-10.)

SPECIFICATIONS FOR CONSTRUCTION APPLY IN MAINTENANCE.

100. All specifications under the section "Construction," whether specifically mentioned under the "Maintenance" chapter or not, in so far as they cover the maintenance field, are to be followed in maintenance. For example, in repairing treads, shape them according to proper design for the region (see Figs. 6 to 10); or in the installation of water bars, follow design shown in Figure 22.

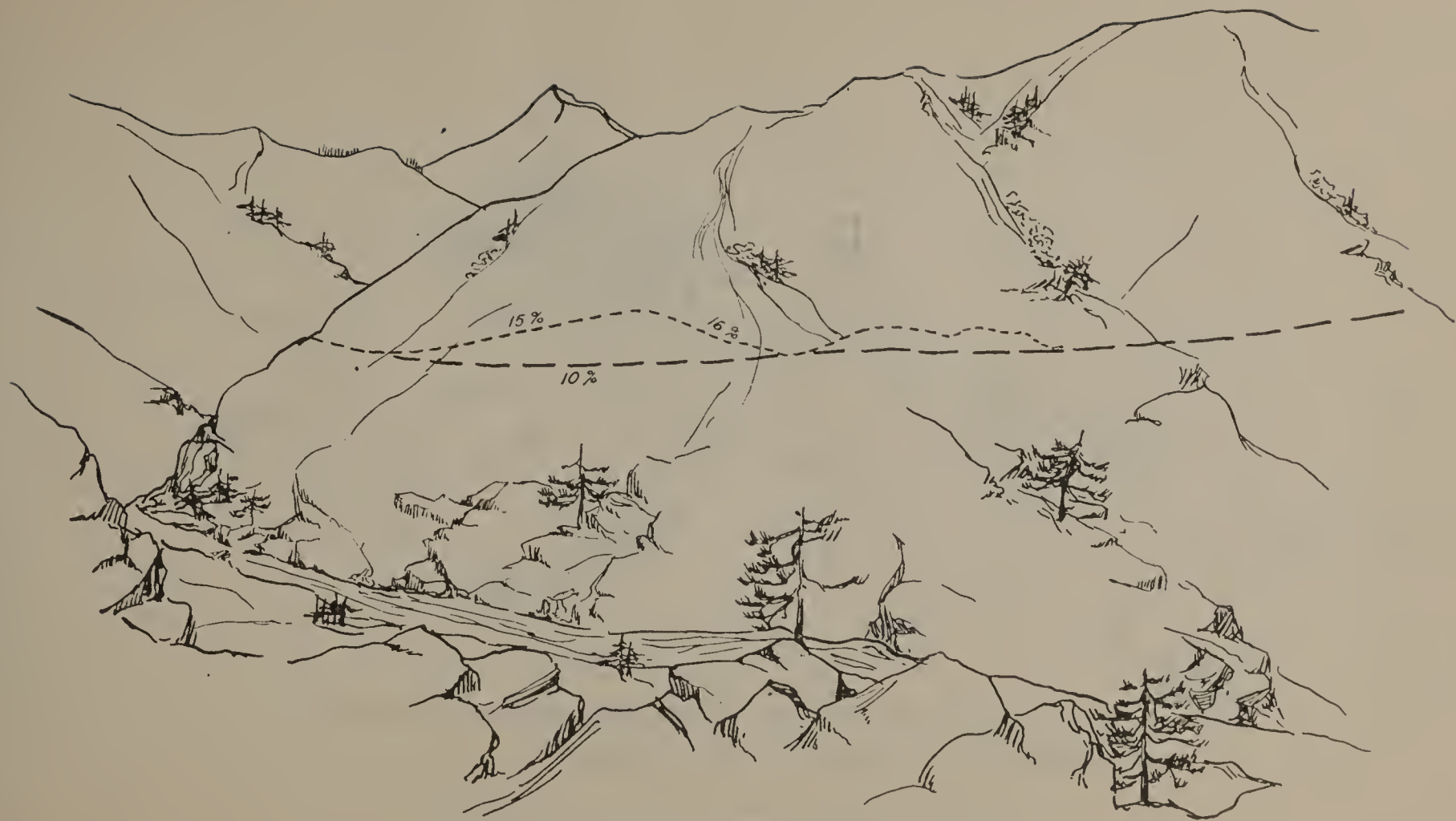
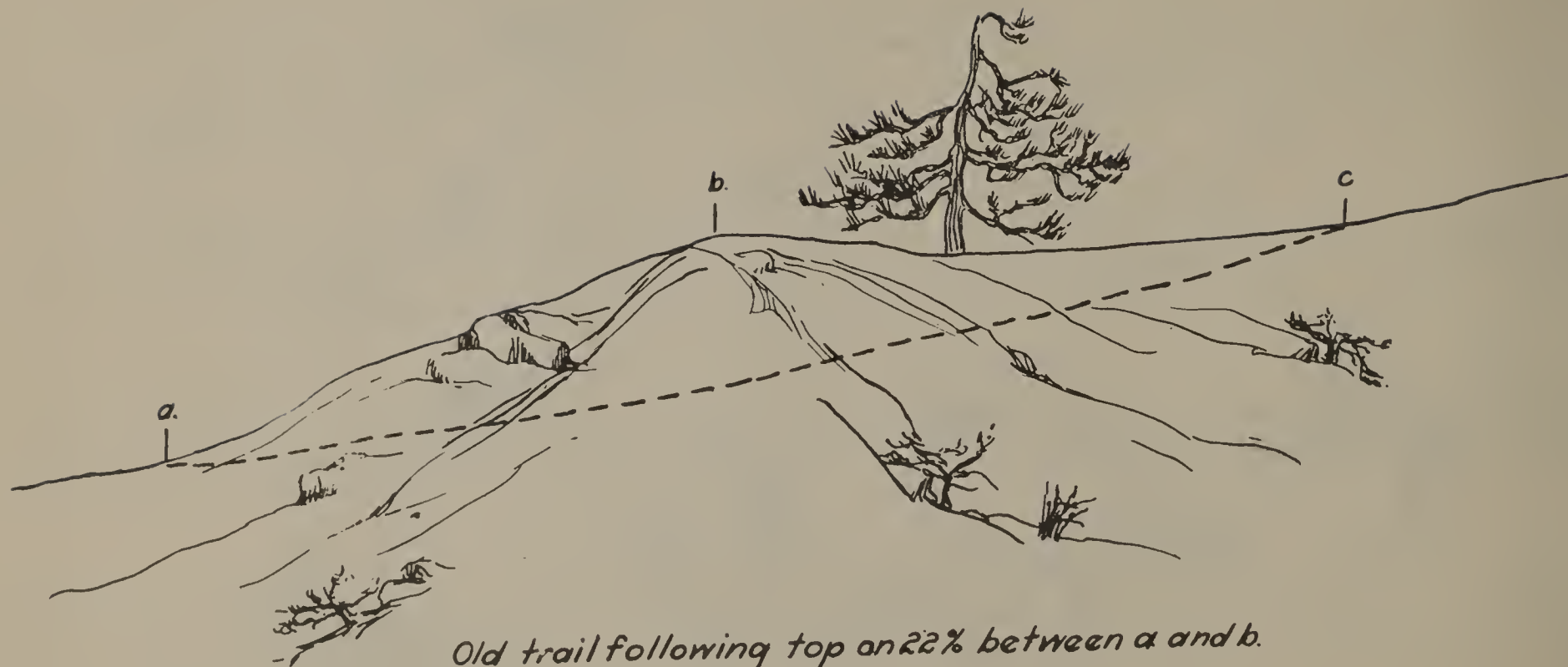


FIG. 33.—Abandonment of existing trails on side hills.



*Old trail following top on 22% between a and b.
Between b and c. undulating.*

FIG. 34.—Abandonment of existing trails on ridges. (Par. 97.)



— Old trail
 - - - Changes made to reduce grade

FIG. 35.—Improving grade on flat ridge. (Par. 98.)

ORGANIZATION FOR MAINTENANCE.

101. Use the type of organization which will do the most work for the least cost on all repair jobs.

ORDINARY.

102. To do ordinary maintenance, if dirt in small quantities only is to be removed, mobile crews composed of three men including a "worker boss" or foreman, equipped with suitable tools and cook outfits and two or three burros for moving camp as work proceeds, have proved to be a very effective and economical form of organization. In this handbook it will be referred to as the "burro system." Use of the system is strongly urged. Where the removal of loose or settled earth from the tread is a material factor, then, if feasible, use plows and scrapers drawn by horses or mules. Under these conditions the "burro system" may or may not be practicable.

103. For light maintenance, not involving much clearing of down timber or dirt work, use of a single man will often be the most economical arrangement.

EXTRAORDINARY.

104. The best organization for this class of work will approximate that outlined for the construction job. Here, too, use plows and scrapers to the fullest practicable limit.

DECREASE OF MAINTENANCE.

105. Need for extraordinary maintenance should gradually grow less if proper attention is given to current repair and reconditioning of the many miles of trails now in bad shape as a result of years of neglect. With extraordinary maintenance of the trail system completed, then, generally speaking, upkeep of trails will fall into the class of ordinary maintenance.

MAINTENANCE UNITS.

106. After needed extraordinary maintenance has been completed the trail systems of a Forest might then be divided into "maintenance units," each unit to receive a thorough going over every fourth or fifth year, as circumstances may require, by crews using the "burro system" or by a single man. Fallen trees will have to be removed and other emergency work done as a matter of course each spring, in addition to ordinary maintenance.

107. Grouping trails in maintenance units may not be practicable for many years in some of the badly burned Forests of the Northwest because each spring the emergency maintenance due to the enormous amount of windfall is such a huge job.

BRIDGES.

108. Construct bridges only where to avoid construction is impracticable. Never build bridges—

(a) To span streams where reasonably safe fords are available during the field season or where they can be provided.

(b) To span gullies and arroyos if physically practicable to cross them by constructing a trail. Balance cost of trail against cost of bridge.

(c) To improve the alignment of a trail by a relatively small amount.

109. As a rule, the district forester will either approve plans and specifications submitted by supervisors or he will prepare plans and specifications for all but very simple bridges. Stringer or king truss structures up to 36 feet in length may be constructed without specific approval of the district forester. Officers selecting sites and designing bridges need to feel a keen sense of responsibility for the permanency or failure of their work. Failure due to controllable errors calls for the application of the principle of personal accountability.

356°—23——5

110. The chief points that locators and designers of simple bridges must keep in mind are:

(a) Minimum length of span providing at the same time for:

1. Stable footing for abutments.
2. Ample clearance above the water line to provide for free passage of drift logs and uprooted trees.
3. Advantage of location where the stream is straight and unobstructed.
4. Minimum cost of new trail for approaches.

(b) Stringers and other members of no less dimensions and in no less numbers than provided in Table 4.

(c) Permanency of foundations.

(d) Treatment of joints with heavy asphalt paint or some other kind of preservative.

(e) Careful study of all instructions of this chapter before going ahead with the job.

STRINGER BRIDGES.

111. This type will be used in the great majority of cases where construction is done by the regular trail crew. Figure 36 shows the approved type to serve as a guide. Six feet is standard width for the floor. This will be exceeded only where use of large stringers make it necessary. Observe the following in every case:

(a) Use rock for abutments and foundations in preference to logs, where possible.

(b) Where abutments and sills are of wood, they should be of the most rot-resistant species available.

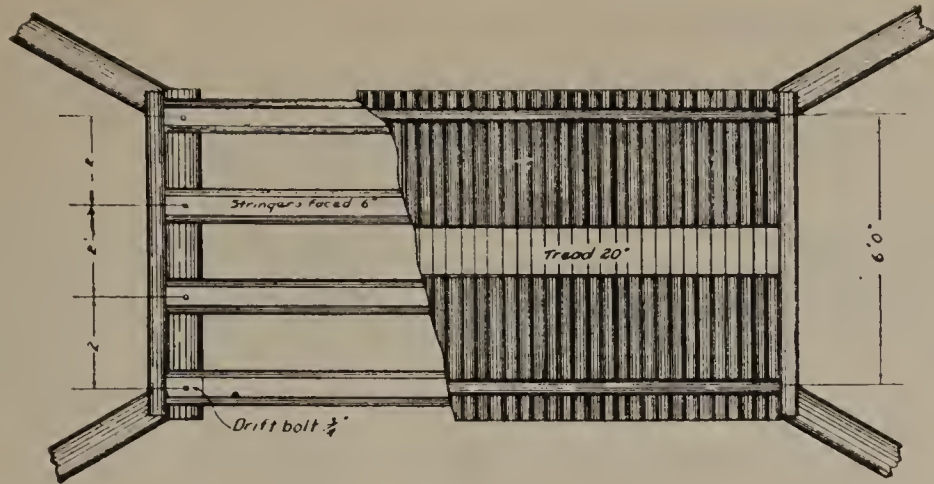
(c) Fills around logs should be of rock and not earth. This permits drainage and reduces rate of decay.

(d) Always peel the bark.

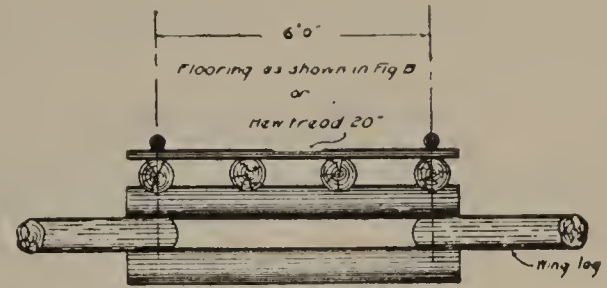
(e) Wood pins or tree nails may be used in place of iron drift pins.

(f) If round material is used for flooring, hew tread along center line about 20 inches wide. Round material split through the center and laid as shown in detail B, Figure 36, also, makes a satisfactory floor. Do not put a dirt covering over floor.

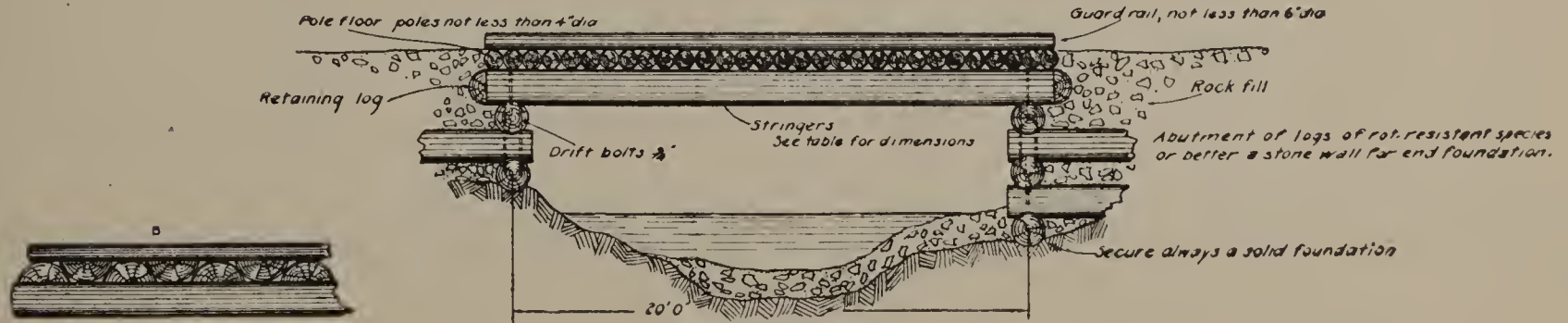
(g) Use four stringers in heavy snow country and where timber is small; also where span is over 20 feet.



Plan
Fig. 38



End View
Fig. 37



Elevation.
Fig. 36

TABLE 5.—*Minimum dimensions for stringers.*

Span, in feet.	3-stringer bridge, 6 feet wide.			4-stringer bridge, 6 to 7 feet wide.		
	Sawed lumber.		Round timber, diameter.	Sawed lumber.		Round timber, diameter.
	Width.	Depth.		Width.	Depth.	
8	3	8	7	3	8	7
10	3	10	8	3	10	8
12	3	12	9	3	12	9
14	4	12	10	4	12	10
16	6	12	11	6	12	12
18	8	12	13	6	12	13
20	10	12	14	8	12	14
22				8	12	15
24				10	12	16
26				10	12	16
28				12	12	17
30				12	12	17
32				12	14	18
34				12	14	18
36				12	14	18

The round-timber diameters are to be measured at the small end after deducting one-half of the diameter of the sapwood.

KING TRUSS BRIDGE.

112. This type should be used only when stringers of adequate dimensions can not be obtained. The cost is much higher than for a stringer bridge and, unless accurately framed, only a small portion of the theoretical strength is developed.

113. Where the snow is exceptionally heavy and portions of the floor can not be removed conveniently in the fall, a truss bridge may be necessary to avoid permanent sag in a simple stringer type.

114. Figure 39 shows an approved plan of this kind of bridge. The same general rules are to be observed here as with stringer bridges.

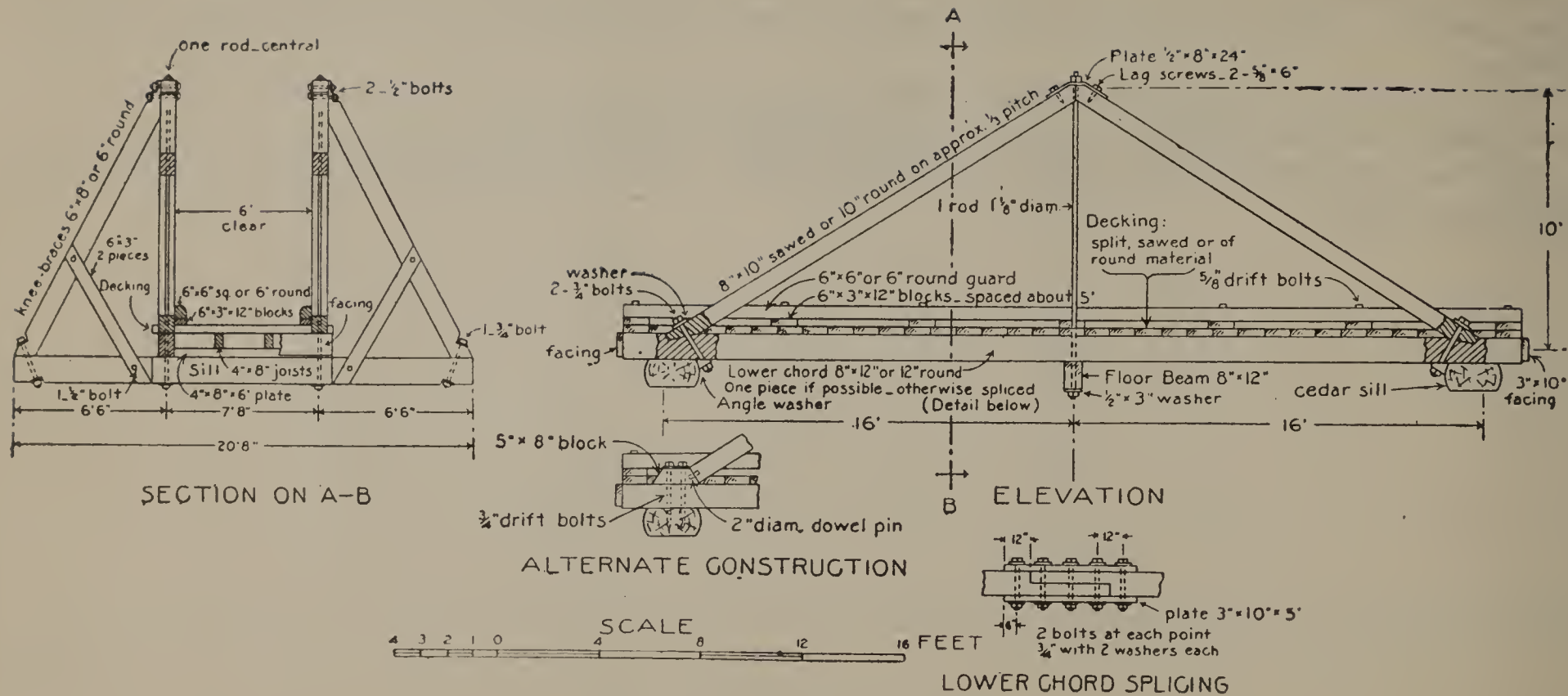


FIG. 39.—Plan of King truss bridge.

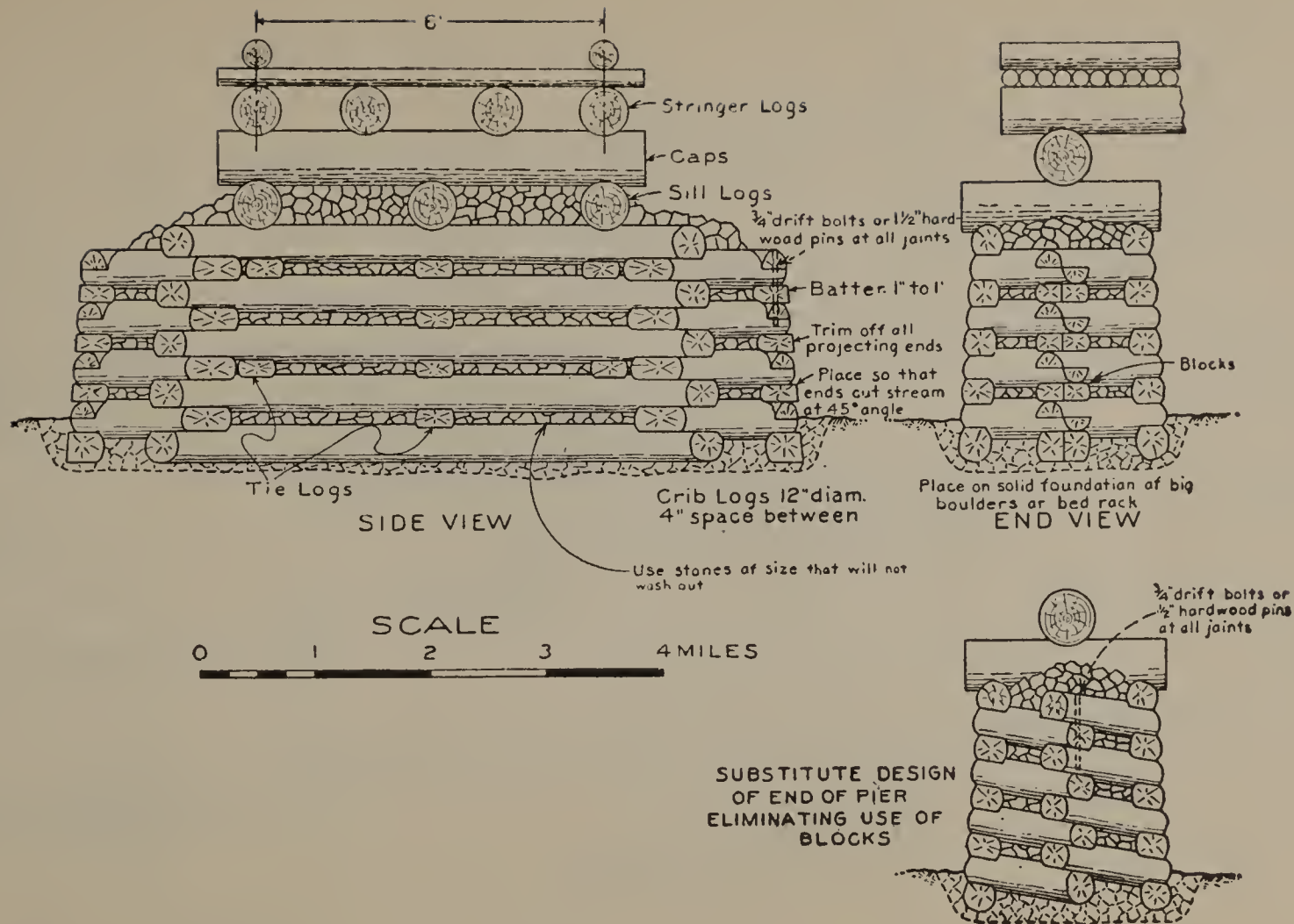


FIG. 39A.—Design of log crib pier, rock filled.

APPENDIX.

TOOLS.

Provide trail and bridge crews with all the tools likely to be needed on any part of the job. Some of the tools may not be used, but it is better to have them on hand when and if required than to lose valuable time securing them or trying to improvise substitutes.

SUGGESTED LISTS OF TOOLS AND EQUIPMENT.

FOR EARTH WORK.

[For a crew of 10 men, including foreman and cook.]

1 or 2 crosscut saws with handles (2-man).
6 d. b. axes.
4 l. h. shovels.
8 mattocks with handles or 8 pick mattocks.
4 picks, railroad or surface, with handles.
4 brush hooks, with handles.
2 cant hooks.
1 carborundum grinder, Niagara No. 4.

4 carborundum whetstones, 4-inch.
12 flat files, 10-inch.
12 flat files, 8-inch; saw filing outfit.
2 wood rasps, 12-inch.
6 d. b. axe handles.
12 mattock handles.
2 augers, 2-inch.

FOR ROCK WORK.

Number of tools based upon assignment of 4 men to rock work, 2 men in each drill crew:

4 ¹ sets drills—112 feet drill steel to make 4 sets, $\frac{3}{4}$ inch or single, $\frac{7}{8}$ -inch for double.	8 gads, 6 feet, $\frac{7}{8}$ -inch drill steel to make 2 6-inch, 2 8-inch, 2 10-inch, 2 12-inch.
2 striking hammers, single jack, $3\frac{1}{2}$ pounds.	2 California crimpers.
2 striking hammers, double jack, 7 pounds.	4 striking hammer handles.
2 rock hammers. 9 pounds.	2 light pinch bars.
2 crowbars, 16 pounds.	2 bull dozers or moils $3\frac{1}{2}$ inches long.
4 drill spoons, 2-30 inch, 2-60 inch.	

BLACKSMITH OUTFIT.

1 short-legged square portable forge.	2 hammers, blacksmiths.
1 vise, weight 40 pounds.	100 pounds blacksmiths' coal.
1 anvil, 50 to 80 pounds, with hardie.	5 pounds welding compound.
3 pairs tongs, blacksmiths', 1-bolt, 1 pick, 1 plain.	Approximate total weight 600 pounds.
1 hot chisel.	

COBBLER'S OUTFIT.

2 lasts.	1 hammer.
1 awl.	Round head nails.

¹ In cutting new steel into sets, the ordinary lengths of drills needed are:

Length (inches).....	12	18	24	30	36	48	(50 in exceptional cases.)
No.	1	2	2	2	2	1	1

TOOLS FOR SMALL BRIDGES WHICH WILL BE BUILT ORDINARILY BY TRAIL CREWS.

[In addition to regular trail equipment.]

Tape, steel, 100-foot.	$\frac{1}{2}$ inch by 8 inches single iron block for traveler.
1-inch auger and handle.	2 steel blocks, $\frac{3}{8}$ -inch—double.
1 $\frac{1}{2}$ -inch auger and handle.	1 carpenter's square.
2-inch auger and handle.	1 carpenter's level.
10-inch broad ax.	3 axes, d. b.
100 feet $\frac{5}{8}$ Manila rope.	1 hand ax.
200 feet $\frac{3}{8}$ extra flexible wire rope.	1 chalk line.
100 feet $\frac{1}{2}$ -inch cable for high line.	2 wrenches, 16-inch.
1 dozen crosby clips.	

TOOLS AND EQUIPMENT FOR ERECTING LARGE TIMBER BRIDGES—SUSPENSION OR TRUSS.

Black diamond drill, steel.	1 dozen hack-saw blades, 12 inch, 18 teeth.
2 double steel tackle blocks, 6-inch, roller bushed with hook and becket, $\frac{3}{4}$ -inch.	1 chalk line.
1 iron snatch block, 8-inch, $\frac{3}{4}$ -inch.	3 pieces chalk.
1 ratchet wrench and set of sockets.	$\frac{1}{2}$ dozen carpenter's pencils.
1 Starrett's square patent combination end wrenches to fit nuts.	$\frac{1}{2}$ dozen black marking crayons.
1 extension hack saw.	1 plumb and level, carpenter's.
1 dozen hack-saw blades, 12 inch, 14 teeth.	2 steel squares, carpenter's.
	2 crosscut saws, 28 inches.
	2 rip saws, 28 inches.

TOOLS AND EQUIPMENT FOR ERECTING LARGE TIMBER BRIDGES—SUSPENSION OR TRUSS—Continued.

- 1 one-man crosscut saw, 5-foot.
- 2 braces, 1 with 12-inch sweep, 1 with 14-inch sweep.
- 1 extension bit.
- 1 bit extension (12 inches in length, if possible).
- 1 snake chain, 6 feet long.
- 1 broad hatchet.
- 1 adz.
- 4 flat files, 8-inch.
- 2 flat files, 10-inch.
- 1 Coes knife handle wrench, 21-inch.
- 2 Coes knife handle wrenches, 10 or 12 inch.
- 1 draw knife.

- 1 jack plane.
- 1 hand winch or single drum winding gear.
- 2 timber carriers.
- 2 wood chisels, $\frac{1}{4}$ -inch, $\frac{1}{2}$ -inch, $\frac{3}{4}$ -inch; 2 1-inch cold chisels.
- 1 carborundum stone.
- 1 carborundum wheel.
- 2 carpenter hammers.
- Fuller's carbosata paint.
- P. and B. paint (asphaltum base).
- 1 broad ax.
- 2 round paint brushes, 2 inches diameter.
- 2 round paint brushes, 1 inch diameter.

TOOLS FOR CONSTRUCTING WOODEN BRIDGES FOR FIVE-MAN CREW.

- 1 adz.
- 1 broad ax, 10-inch.
- 4 d. b. axes, $3\frac{1}{2}$ -pound.
- 1 crosscut saw, 6-foot.
- 1 bridge carpenter's saw, 4-foot.
- 2 cant hooks.
- 1 set ship carpenter's augers, long sharps.
- 1 carpenter's square.

- 1 hand ax.
- 1 carpenter's hammer.
- 1 steel tape, 100-foot.
- 1 chalk line and chalk.
- 1 slick.
- 6 files, 8-inch.
- 1 brace 14-inch sweep.
- 1 set carpenter bits.

TOOLS FOR CONSTRUCTING WOODEN BRIDGES FOR FIVE-MAN CREW—Continued.

- 1 monkey wrench, 16-inch.
- 1 monkey wrench, 8-inch.
- 1 carpenter's hand saw.
- 1 crosscut file and outfit.
- 1 carpenter's level.
- 300 feet of $\frac{1}{2}$ -inch steel cable for high line.
- 2 iron blocks, $\frac{1}{2}$ -inch by 8-inch.

If team is used on heavy timber bridge the following equipment is needed:

- 400 feet $\frac{3}{8}$ -inch cable (pull cable).
- 1 single block (iron), $\frac{3}{8}$ -inch.
- 1 double block (iron), $\frac{3}{8}$ -inch.
- 1 snatch block (iron), $\frac{3}{8}$ -inch.
- 1 chain ($\frac{1}{2}$ -inch) and timber dogs for team yarding.
- 100 feet $\frac{3}{4}$ -inch rope.
- 1 single block (for rope), $\frac{3}{4}$ -inch.
- 1 double block (for rope), $\frac{3}{4}$ -inch.
- 1 metallic tape, 50-foot.
- 2 slicks, narrow and wide.
- 1 chisel, 2-inch framing.
- Ship augers for deep holes.
- 1 two-way brace.
- 1 bit-rabbit plane, $1\frac{3}{4}$ -inch, wood frame.

- 2 braces, 10-inch.
- 1 saw set (Morril).
- Saw files (several).
- 2 cant hooks.
- 2 sets long and short auger bits.
- Marlin.
- 1 Abney level.
- 2-inch bit for notches in posts for struts.
- Steel wire brushes for cleaning iron.
- Bit stop for boring holes to any set depth in wood.
- 2 sets of steel blocks and $\frac{3}{8}$ -inch flexible wire rope, 400 feet.
- Plenty of rope.
- 1 set of taps and dies for bolts.
- 1 vise.
- Extra handles, especially for chisels and all tools.
- Steel wool for cleaning tools.
- Some extra bolts and a large number of extra nuts.
- Log chains (several needed).
- 1 snatch block, $\frac{3}{8}$ -inch steel.
- 1 steel tape, 100-foot.
- 1 hand hoist or crab.
- 300 feet $\frac{1}{2}$ -inch wire rope for high line.
- 2 steel single blocks, $\frac{1}{2}$ -inch.

TENTAGE.

[Suggested only.]

- | | |
|--|--|
| 1 wall tent, 12 by 14 foot, with or without fly, for cook tent. | 1 wall tent, 8 by 10 foot, with or without flies for provision |
| 1 wall tent, 12 by 14 foot, 14 by 16 fly for mess shelter. | tent. |
| 3 wall tents, 8 by 10 foot, with or without flies for sleeping quarters. | |

INDEX.

	Par.		Par.
Abney level, use of.....	32	Classification:	
Applicability of specifications.....	7, 8	Care in.....	28, 29
Bad practice.....	92	Primary and secondary.....	27
Back slope, finishing of (Fig. 13, p. 31).....	71, 72	Responsibility for.....	29
Blacksmithing, how to do.....	49	Clearing:	
Blasting, stumps.....	53	Brush-disposal policy.....	63, 64
Blazing (Figs. 27, 27a, pp. 47, 48).....	88, 89	Height of overhead.....	59
On graded trails.....	89	Limits of.....	59
Bogs, avoid.....	34	Rule for.....	59
Use of rock in.....	83	Stump—	
Bridges.....	108	Heights of.....	60
Designing of.....	109	Blasting of (Fig. 4, p. 23).....	61
King truss (Fig. 39, p. 68).....	112-114	Tree felling (Fig. 4, p. 20).....	62
Length, limits.....	109	Communication to crews.....	19
Location of.....	108-110	Construction:	
Painting joints of.....	110	Applicability of instructions.....	39
Permanency of.....	109	On level ground (Table 2, p. 22).....	
Responsibility for.....	109	On ridges.....	46, 98
Stringer bridges (Fig. 36, p. 65, Table 5, p. 66).....	111	On rock slides or rubble.....	68
Stringer, dimensions of (Table 5, p. 66).....		On slopes under 30 per cent (Table 2, p. 22).....	
Brush:		On slopes over 30 per cent (Figs. 6-9, pp. 23-26).....	
Burning.....	63, 64	Crews:	
Disposal.....	63, 64	Fire fighters.....	17, 18
Piling.....	63, 64	Payment of, on fire.....	18
Burro system of maintenance.....	102	Size of, in construction.....	48
Camps:		Size of, on maintenance.....	102, 103
Comforts of.....	92	Cross sections:	
Adjacent to work.....	57	Special for southwest (Fig. 9, p. 26).....	
Sanitation.....	58	Standard (Figs. 6-8, pp. 23, 25).....	

	Par.		Par.
Culverts, use of.....	82	Excavation:.....	92
Dangerous places, repair of.....	95	Undercut method.....	92
Design of trail (Figs. 6-10, pp. 23-27).....	92	Position of grader.....	92
Digging methods.....	27	Finish of trails (Figs. 6-10, pp. 23-27).....	19
Definition of trails:.....	27	Fire-control equipment for crews.....	92
Primary.....	27	Food standards.....	47
Secondary.....	27	Foot trails, grades of.....	26, 38
Dirt rail, use of (Figs. 6-7, pp. 23-24).....	16	Form 428, use of.....	
Driveways.....		Fords:.....	87
Drags:.....		Selection of.....	87
Trail (Fig. 40, p. 70).....	20, 24, 99	Use.....	92
Use of.....		Good practice.....	
Drainage:.....		Grades:.....	97
In gullies (Fig. 23, p. 40).....	85	Abandonment of old.....	45
On swampy flats.....	79	Along creeks.....	46, 98
Open ditches for side hill seepage.....	78	Along ridges.....	41, 42, 51, 52
Types of structures.....		Designation of (Fig. 2, p. 15).....	47
Water bars—.....		For foot trails.....	47
Design (Figs. 21-22, pp. 38, 39).....	80	For stub trails.....	32
Placing.....	89	Instruments needed for running.....	33
“Ducks,” use of, above timber line.....		How to determine.....	44
Durability, specification for (Figs. 6-10, pp. 23-27).....		Maximum of (Table 1, p. 16).....	41, 42, 51, 52
Equipment:.....		Marking of.....	42
Blacksmith outfits (p. 72).....		Primary trails (Table 1, p. 16).....	44, 46
Bridges (pp. 74, 75).....		Reverse, use of.....	43
Cobbler's (p. 72).....	19	Secondary trails (Table 1, p. 16).....	40, 42
Fire-control crews.....		Staking of.....	43
Earth work (p. 71).....		Standards.....	47
Rock work (p. 72).....	92	Stub trails.....	43
Supply, adequate.....		Use of 15 per cent.....	44, 47
Tentage (p. 76).....		Use of over 15 per cent.....	16
Erosion at water bars, to prevent.....	81	Grazing projects.....	16
Estimates:.....	37	Specification for.....	73
Accuracy of.....	38	Guard rails, use of.....	73
Details of.....	37	Guard walls, use of.....	
Responsibility for.....	38	Horses:.....	23
Use of card, Form 428.....		Purchase of.....	23
		Use of.....	

	Par.		Par.
Instrument for location.....	32	Obstacles in tread of trails, removal of (Figs. 6-9, pp. 23-26).....	99, 100
Lines between stakes, use of.....	42	Organization:	
Location:.....	30	For blacksmithing.....	49
Care in.....	30	For clearing.....	50-55
Cost of, justifiable.....	44	For grading.....	52
Control points for.....	31	For finishing or trimming.....	50
Importance of.....	30	Maintenance.....	102-106
Instruments for.....	32	For powder men.....	53
Place of forest supervisor in.....	5	For swamping.....	5-55
Place of rangers in.....	5	Size of crews.....	48, 102
Places to avoid.....	34, 84, 85	Passing places.....	69, 70
Places to favor.....	34, 35	Payment of trail crews on fire suppression.....	18
Principles of (Fig. 1, p. 12).....	36	Permanency of bridges.....	109
Qualifications necessary.....	4	Plans—maps.....	25, 26
Trails, not roads.....	36	Plows, use of.....	12, 20, 24
Log cribbing (Fig. 39a, p. 69).		Post setting for signs (Figs. 31, 32, p. 51).	
Maintenance:		Prevention of erosion as water bars.....	81
Classification.....	94	Poles in fills, bad practice.....	92
Burro system of.....	102	Primary trails defined.....	27
Dangerous place, repair of.....	95	Progress in trail work.....	3
Decrease in.....	105	Purpose of the handbook.....	1
Emergency defined.....	94	Purpose of trails.....	9
Extraordinary defined.....	94	Profiles to get best (Fig. 2, p. 15).....	42
On ridges.....	98	Proof of, inapplicability of specifications, burden of.....	8
Ordinary defined.....	94	Qualifications needed in personnel for trail work.....	4
Organization for.....	101, 103, 106	Ranger working on trails, policy.....	6
Plows, use of in.....	99	Reconnaissance, need for.....	31
Scraper, use of in.....	99	Reconstruction.....	13
Units.....	106, 107	Dangerous places.....	13, 95
Maps and plans.....	26	Relocation.....	13, 96
Marking systems.....	88, 89	Steep pitches to eliminate.....	97
On reconnaissance.....	88	To make a trail look better.....	97
Measuring width (Fig. 5, p. 21).....	92	To get better grades on ridges.....	98
Monument, use of, above timber line.....	89	Recreation trails.....	15
Need for trails by classes.....	2	Justifiable width of.....	65, 66
For trails relative.....	2	Relative need for trails.....	2
Objects of trail construction.....	9		

	Par.
Relocation.....	13, 96, 97
Justifiable work.....	13, 96, 97
On broad ridges.....	98
Removal of obstacles from tread.....	12, 99
Responsibility:	
For classification.....	29
For estimates.....	37
Of forest officer for location.....	5
Of forest officer for application of specifications.....	8
Rock in boggy places.....	83
Rock slides (Figs. 11, 12, pp. 29, 30).....	68
Rock walls:	
Specification.....	75, 76
Where to use.....	74
Rocks on outer edge (Figs. 6, 7, pp. 23-24).....	
Roots, removal of, from trail (Table 2, p. 22; Figs. 6, 7, 9, pp. 23, 24, 26).....	
Sanitation of camps.....	58
Seasons, trail program.....	17
Secondary trails:	
Defined.....	27
Finish of.....	67
Selection of projects:	
Administrative.....	14
Fire control.....	14
Grazing and driveways.....	16
Maintenance.....	2, 11
To get crews in proper place.....	17
Scraper, use of.....	12, 20, 24, 99
Shovels, use of.....	92
Signs:	
Height of.....	91
Metal to be backed.....	91
Placing (Figs. 28-30, p. 50).....	91
Position.....	91
Posts for (Figs. 31, 32, p. 51).....	91
Size of crews.....	48, 102, 103, 106

	Par.
Southwestern region, cross section for trails (Fig. 9, p. 26).	
Standards:	
Of construction.....	10
Of maintenance.....	11
Of grades.....	44-47
Of widths (Table 2, p. 22; Figs. 6-9, pp. 23-26).....	
Staking:	
At time work commences.....	40
At control points.....	40
Interval for.....	41
Line between stakes (Fig. 2, p. 15).....	42
Spacing.....	41
Stationing men.....	52
Stock trails:	
Merits of.....	16
Specifications of.....	16
Stumps:	
Blasting (Fig. 4, p. 20).....	61
Heights.....	60
Surveys:	
Forest officers' responsibility for.....	5
Instruments for.....	32
Marking of.....	40, 88, 92
Obstacles to avoid.....	34
Situations to favor.....	34
Use of rags to mark preliminaries.....	88
Switchbacks:	
Guardrail for (Fig. 14, p. 33).....	73
Length of.....	34
Protection for (Figs. 14, 15, pp. 33, 34).....	73
Telephone connection to crews.....	19
Tentage (p. 77).....	
Time:	
Factor to warrant project.....	9, 13, 36
Saved by trail work.....	9, 13, 36
The job.....	4

Tools:		Par.	Trails—Continued.	Par.
Adequacy of.....	92	92	Use of rock on outer edge (Figs. 6-9, 12, pp. 23, 26, 30).....	92
For location.....	32	32	Use of scraper or drags.....	12, 20, 24, 99
Sharpness of.....	92	92	Use of wheelbarrows.....	92
Trail crews as fire fighters.....	17	17	Use of rags or paper on surveys.....	92
Trails:			Walls, rock (Figs. 16-19, p. 35).....	74-77
Class defined.....	27	27	Water bars:	
Rate of travel on.....	9, 13, 36	9, 13, 36	Angle of.....	80
Single-file travel.....	9, 13	9, 13	Erosion by, prevention of.....	81
Foot, grades of.....	47	47	Types (Figs. 21, 22, pp. 38, 39).....	
Primary defined.....	27	27	Wheelbarrows, use of.....	92
Primary specifications for (Figs. 6-10, pp. 23-27; Tables 1, 2, pp. 16, 22).....			Why trails are built.....	9
Secondary specifications for (Tables 1, 2, pp. 16, 22).....	67	67	Work on trails by rangers.....	5, 6
Stubs, grades of.....	47	47	Written instructions to foreman.....	8
Undercut method.....	92	92	Width:	
Use of dirt rail (Figs. 6, 7, pp. 23, 24).....	92	92	As related to slope.....	66
Use of precise method.....	4	4	How to measure (Fig. 5, p. 21).....	65
Use of dull tools.....	92	92	Of grazing trails.....	16
Use of handbook.....	7, 8	7, 8	Of recreation trails.....	66
Use of plows.....	12, 20, 24, 99	12, 20, 24, 99	Of secondary trails.....	67
Use of powder.....	92	92	Of stock trails.....	16
Use of shovels.....	92	92	Specifications for (Table 2, p. 22; Figs. 5-10, pp. 21-27).....	
			Standards for.....	66

ADDITIONAL COPIES

OF THIS PUBLICATION MAY BE PROCURED FROM
THE SUPERINTENDENT OF DOCUMENTS
GOVERNMENT PRINTING OFFICE
WASHINGTON, D. C.

AT

25 CENTS PER COPY

PURCHASER AGREES NOT TO RESELL OR DISTRIBUTE THIS
COPY FOR PROFIT.—PUB. RES. 57, APPROVED MAY 11, 1922



